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The MORE IMPORTANT APPLE INSECTS

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Washington, D. C. September, 1922

THE MORE IMPORTANT APPLE INSECTS.

By A. L. Quaintance, *Entomologist in Charge*, and E. H. Siegler, *Entomologist, Fruit Insect Investigations, Bureau of Entomology.*

THE APPLE CROP AND LOSSES FROM INSECTS.

THE APPLE, KING OF FRUITS, has assumed a high rank among American agricultural products. In the United States its average monetary value over the five-year period 1914–18 has been placed at about $185,000,000,[a] or approximately one-half the estimated worth of the potato crop. The financial success of the apple industry is dependent, however, upon several factors, and among these insects play an important rôle. The annual loss to the apple crop through insect ravages is somewhat variable, changing from year to year, not only in the large fruit-growing districts but in individual orchards as well. Although it is extremely difficult to estimate the yearly loss due to insects, a fairly conservative estimate would place it at about 10 to 20 per cent of the crop value, or, at the lower figure, about $18,000,000. To this should be added the loss of the trees themselves as the result of infestations of apple-tree borers, scale insects, etc., and the considerable amount expended for spraying apparatus, insecticides, and labor.

In the present bulletin an attempt has been made to acquaint the fruit grower with the general distribution, description, life history, and control of the apple insects with which he is likely to be troubled. The orchardist would do well to study carefully the insects causing important injury, in order that remedial measures may be intelligently applied.

CODLING MOTH.[1]

The codling moth, or "apple worm" as it is commonly called, is unquestionably the most serious insect enemy of the fruit of the apple and annually destroys or renders unfit for commercial purposes millions of dollars worth of fruit, despite present efforts to control it by spraying. It should not be inferred, however, that spraying measures are ineffective, for it has been amply demonstrated that thorough and timely spraying will usually yield from 90 to 95 per cent and often more of worm-free fruit, except in some of the semiarid regions of the West where this insect is unusually abundant and destructive. In the absence of combative measures, the codling moth will frequently infest from 25 to 90 per cent or more of the fruit, depending upon the locality, seasonal and weather conditions, size of the crop, and other contributing factors. Apples infested with this insect are commonly called "wormy apples" (figs. 1, 2, and 3), but to avoid possible confusion it should be borne in mind that this fruit may be wormy through infestation by other pests, as the apple maggot (p. 13), lesser apple worm (p. 10), etc.

Shortly after hatching from the egg, the larva or worm eats its way into the flesh of the apple, usually feeding in the direction of the core, and on reaching it frequently attacks the seeds. A considerable but variable propor-

[1] *Carpocapsa pomonella* Linnaeus.

[a] Folger and Thompson, The Commercial Apple Industry of North America, p. 3. 1921.

tion of the first brood enters through the calyx or blossom end, while the later or summer brood worms apparently prefer to enter through the side of the apple. A favorite place of entrance is at the point where two apples are in contact. As the codling-moth larva tunnels through the fruit, it grows and makes a correspondingly larger feeding area, which becomes more or less packed with dark reddish brown to blackish pellets, which are gradually pushed out toward the entrance hole. Upon attaining their full growth, some larvæ leave the fruit by way of their entrance holes, while others make their exit at another point, thus producing in the same apple two holes, an entrance and an exit. Another type of injury frequently found in the semi-arid fruit regions of the West, and other fruit districts where the codling moth is abundant, is known as the "sting" and the affected apples are called "stung" fruit. The typical "sting" is caused by a worm eating a small hole (about the size of a pinhead) through the skin of the apple, after which it makes a shallow excavation in the flesh to the depth of about one-sixteenth to one-eighth of an inch and sufficiently large to accommodate the body of the young worm. These so-called "stings" are frequently made by larvæ that have been poisoned but which are able to complete the "sting" pocket before dying from the effects of the arsenical. Occasionally worms complete a "sting" pocket and then for some unknown reason leave it to enter the fruit at another point. It is also quite possible that some larvæ after having eaten through the skin are washed off by heavy rains or are blown or brushed off during windstorms. Although apples having a few "stings" usually are not damaged seriously except perhaps as to keeping qualities, they are nevertheless discriminated against by the buyers and placed in a lower grade, thus making this type of injury of commercial importance.

FIG. 1.—Wormy apple caused by codling moth larva entering calyx end of fruit.

Some codling-moth larvæ feed to a certain extent upon the foliage of the apple previous to their attack upon the fruit. They usually eat into the lower surface of the leaf, either along the midrib or at the juncture of a vein with the

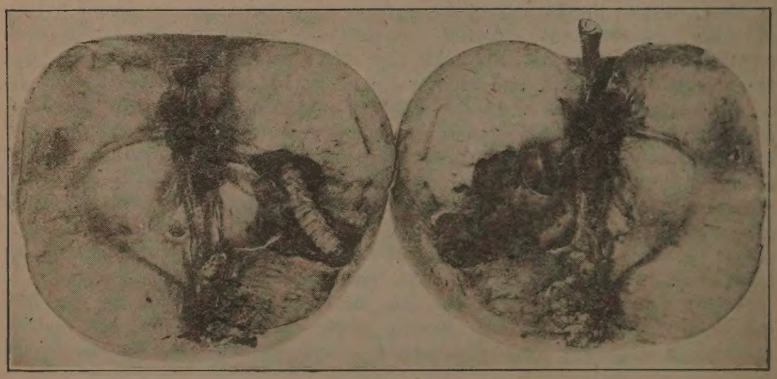

FIG. 2.—A worm-injured apple, showing codling moth worm in fruit (left half).

midrib. This leaf-feeding habit is of negligible importance as to foliage injury, but it is of some consequence from the control standpoint in that some larvæ may be killed or weakened by eating the poison before they reach the fruit.

The codling moth passes the winter in the larva stage, inclosed in a silken cocoon (fig. 4), which is about three-fourths of an inch in length. The overwintering larva is about the same length as the cocoon and is usually of a dirty white color with a brown head. The larvæ normally make their cocoons beneath the bark scales of the trunk and larger limbs, in tree crotches, and in decayed stubs resulting from improperly pruned limbs; they also spin up in trash about the orchards, in cracks of the soil adjacent to the tree, in field harvest boxes, in packing houses, etc. In the spring the larva transforms successively into the pupa (fig. 4) and moth stage (fig. 5). The pupa is about half an inch in length and varies in color from dark yellow to brown. The abdominal segments are movable and each is provided with a double row of spines, except the terminal segments, which have but one each. The moth is somewhat variable in size, but the wing expanse averages about three-fourths of an inch. The front wings are crossed by irregular dark and light bands except the tips, each of which bears a dark metallic brown spot or ocellus. The moth, which is seldom seen by the orchardist, usually conceals itself in or about the tree during the day, but becomes more active about twilight, when it deposits a majority of its eggs. These are laid on both the leaves and fruit, the first-brood eggs being usually found on the foliage, while those of the summer brood are as a rule deposited on both the fruit and foliage. The egg is about the size of a pinhead, flat, round to oval in shape, the surface being covered with a network of ridges, and when freshly laid is pearly white in color. The young larva which hatches from the egg feeds chiefly upon the fruit, and after attaining its full growth leaves the apple and spins its cocoon on the tree trunk or in other places, as elsewhere noted. In districts having two or more generations, part of the first-brood larvæ soon transform to pupæ, while the others remain in the larva stage until the following spring. Those that transform the same season as hatched produce a new generation. In the more northern fruit-growing districts of the United States, as in New England, there is a small second generation, whereas in some of our extreme southern regions, as in the Pecos Valley of New Mexico, as many as three generations and a partial fourth may develop. In any locality the relative abundance of worms, especially those developing late in the season, varies from year to year, largely in accordance with the weather conditions. If the season is early, dry, and hot, a larger number of worms than usual will be produced, whereas during late, cool, and wet seasons the reverse is true. The orchardist should therefore study the seasonal weather conditions, and if these are favorable to the codling moth supplemental spray treatments should be applied.

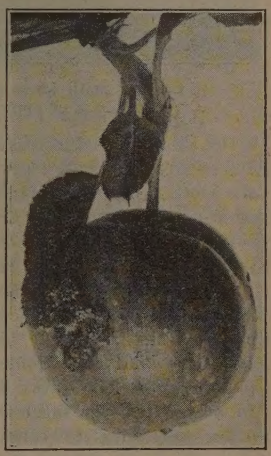

FIG. 3.—Apple infested with the codling moth. Note frass pushed out of larval burrow.

The length of the different stages of the codling moth varies with the climatic conditions. In the spring the pupa stage averages about 3 weeks, with an approximate range from 2 to 6, while later in the season this stage

is shortened to an average of about 2 weeks. The incubation period of the egg during the relatively cool spring weather will frequently extend over 2 weeks, although the average period is usually about 8 or 9 days. Later in the season this average is reduced to 6 or 7 days, and there are records in the Bureau of Entomology of an incubation period as low as 4 days. The feeding period of the larva is also prolonged in the spring, sometimes almost to 2 months, with an average of about 3 to 4 weeks, while during the summer the larvæ usually complete their feeding within about 3 weeks.

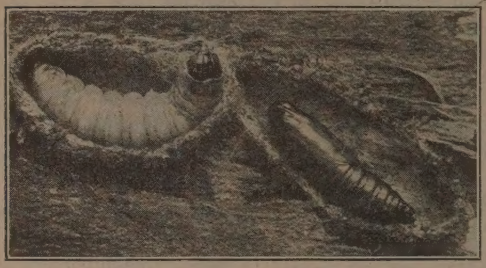

FIG. 4.—Codling moth larva and pupa within cocoons beneath bark of apple tree. Enlarged.

The control of the codling moth is largely effected by spraying with a poison, such as arsenate of lead, described on page 83. The number of spray applications required to secure satisfactory results will vary with the locality, the number of generations, and the relative abundance of the insect. In the northern latitudes good control is frequently obtained with from one to three applications, whereas in districts having longer seasons, or wherever the moth is naturally abundant, as in the semiarid valleys of the West, it is often necessary to spray from five to seven times.

The time of the application is very important, and although no definite schedule that will meet satisfactorily the conditions obtaining in all parts of the country can be given here, the following suggestions will be of value. The first application should be made in every orchard just after the blossoms have dropped (fig. 180) and this application should be completed before the calyx lobes close (fig. 181). In order to cover large orchards in time it is often necessary to commence spraying when only 85 to 90 per cent of the blossoms have fallen, but care should be taken not to spray when the trees are in bloom and attractive to bees. The object of this application is to deposit in the calyx cup a quantity of poison sufficient to kill all the larvæ that endeavor later to enter the apple through the calyx end. The calyx cup is open at the time the blossoms drop, but is closed about a week later, after which it will be too late to force the poison into the cavity. No subsequent spray can be of much value in preventing calyx worms, hence the great importance of this application.

FIG. 5.—Codling moth resting on apple leaf. Enlarged.

The first larvæ or worms begin to hatch in most sections about 3 to 4 weeks after the blossoms have fallen, although in some districts, and particularly if the weather is warm, a few worms will commence to hatch in from 2 to 3 weeks following the fall of the bloom. The second spray should therefore be applied in from 2 to 4 weeks after the first in order to coat the leaves and young fruit with poison just previous to the hatching of the early worms. In fruit districts where the insect is difficult to control, one or two additional

applications against the first brood should be made so as to provide a fresh covering of poison during the period when these worms are attacking the fruit in large numbers. It is highly important to spray thoroughly against the first-brood worms so as to reduce their number to a minimum, since this brood is the sole progenitor of the later generations.

The second-brood worms begin to hatch about 8 to 10 weeks after the petals have dropped. In some of the Northern States there may be so few of these as to render it unnecessary to make a special application for them. In most fruit districts, however, it is essential to spray at this time, and in heavily infested regions an additional application for the second brood should be made in time to have the fruit covered with poison when the worms are hatching in maximum numbers. Additional spray applications will usually be necessary where there are three and four generations, but care should be taken that spraying is not done too close to the harvest season, so as to avoid the presence of spray residue on the marketed fruit.

Arsenate of lead at the rate of 1 pound of the powder or 2 pounds of the paste to 50 gallons of water or fungicide is recommended for the control of the codling moth. The powdered form is preferable to the paste, since it is more convenient to use and can be kept more easily from one season to another without deterioration. It is usually desirable in commercial practice to combine arsenate of lead with a fungicide such as dilute lime-sulphur or Bordeaux mixture, and often with a contact insecticide, like nicotine sulphate, for the simultaneous treatment of chewing and sucking insects and the prevention of the common fungous diseases. (See spray schedules, pp. 86 and 90.)

A power sprayer having sufficient capacity and pressure is essential for commercial orchards. This should be equipped with well-made hose and couplings, and if the trees are large should be provided preferably with a spray tower (fig. 178), so that the higher parts of the trees may be treated thoroughly.

In badly infested regions spraying is sometimes supplemented with the so-called "banding method," which consists in placing around the tree trunk a burlap band under which many of the worms will collect after they leave the fruit. These bands should be examined at regular intervals and the insects found beneath destroyed. The orchardist should bear in mind that many of the worms beneath the bands soon become moths and that unless they are destroyed before they reach this stage the moths will escape and deposit more eggs.

During the harvest, many worms leave the fruit while it is being handled in the packing house. These worms spin up for the winter in field boxes and other containers and in cracks and crevices of the packing house. By early summer they will have become moths which, if not confined, will fly to the orchard and deposit eggs. If feasible, the escape of the moths should be prevented by screening the windows and closing up any other possible exit.

PLUM CURCULIO.[2]

The plum curculio probably ranks in importance next to the codling moth as an apple pest and is responsible for much of the misshapen and gnarly fruit (fig. 6) that is commonly found in orchards. It is a native species and feeds upon plums, haws, etc. While the plum curculio attacks the apple and other pome fruits, it is especially injurious to the stone fruits, and in addition to these is also reported from other hosts. It is widely distributed in the States east of the Rocky Mountains, but is not known to occur farther west.

[2] *Conotrachelus nenuphar* Herbst.

The injury to the apple is chiefly confined to the egg punctures (fig. 7), made by the females in the spring, and the feeding punctures, made by both sexes in the spring and fall. The egg puncture (fig. 8) is made by the snout of the female and is very distinctive, consisting of a small cavity or hole in the flesh of the fruit just below the skin. The female then cuts with her snout a small crescent-shaped incision just in front of the place where the egg was deposited. The feeding puncture is a small circular opening about the size of a pinhead, extending into the flesh of the apple for a distance of about one-sixteenth of an inch and is produced by the snout of the beetle in the course of its feeding.

Fruit that is badly punctured early in the season is likely to drop and many of the larvæ that hatch therein develop to maturity, since the fallen fruits furnish conditions favorable to the growth of the grubs. The punctured fruit remaining on the tree is usually dwarfed and gnarly in appearance, but the curculio larvæ seldom if ever develop to maturity in it. Late varieties of apples sometimes outgrow the egg punctures more or less, though many of them are conspicuous at harvest as irregular, yellowish brown, corky areas, often somewhat elevated above the surface of the apple. The fall feeding puncture (fig. 9) of the curculio differs from the spring feeding puncture and is fairly characteristic. The beetles prefer the calyx or stem ends, where small holes are eaten through the skin, under which, with the hole as a center, the flesh is eaten out as far as the length of the beetle's snout will permit. This results in a discolored ring of skin around the opening, which may later become enlarged into a shallow pit, as it becomes invaded with decay-producing organisms. These pits may be further excavated by the beetles, and the latter can often be found feeding or resting in them. The beetles also feed on the foliage in the spring and fall, eating out small, circular holes.

The plum curculio spends the winter in the adult or beetle stage, usually hibernating in protected places, as beneath trash in orchards or in near-by woods. The adult (fig. 10) is a small, brownish snout-beetle and varies somewhat in length, averaging about one-fourth of an inch. Early in the spring the beetles emerge from their hibernating quarters, some of them reaching the apple trees before the blossoming period. As soon as the young fruit is set, the beetles attack it, as previously described. The curculio egg is elliptical in shape, whitish in color, with a smooth, shiny surface, and measures about one-fortieth of an inch in length by one-sixtieth of an inch in width. A full-grown larva is about five-sixteenths of an inch in length, footless, yellowish white in color, with a brownish head. Upon completing its feeding period, the larva leaves the fruit and enters the soil, forming a pupal cell, in which it transforms successively to the pupa and adult stages. The pupa is whitish in color and about three-sixteenths of an inch in length. The adults emerge in 2 or 3 weeks, and in the far South some individuals deposit eggs giving rise to a second generation. The beetles feed upon the fruit and foliage until the approach of cold weather, when they seek hibernating quarters.

The most practical means of control are spraying with arsenate of lead and the cleaning up of trash from the orchards and vicinity, as well as thorough cultivation during the summer. Destruction of trash removes favorable hibernating quarters, while cultivation at the proper time will kill the delicate pupæ within the soil. The prompt collection and destruction of the infested, fallen fruit will also aid in reducing this pest. The first spray application to poison the beetles should be applied in the pink cluster-bud stage, and the second as soon as the blossom petals have dropped, using arsenate of lead at the

FIG. 6.—Apples deformed by the plum curculio.

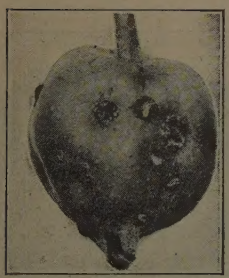

FIG. 7.—Egg punctures made by the plum curculio.

FIG. 9.—Fall feeding punctures of the plum curculio.

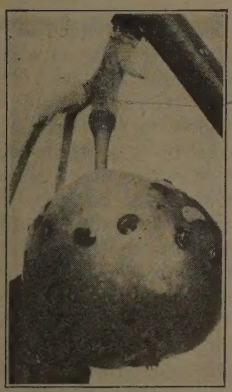

FIG. 8.—Egg punctures made by the plum curculio.

FIG. 10.—The plum curculio on peach. Enlarged.

rate of 1 pound of the powder or 2 pounds of the paste to 50 gallons of water or fungicide. Supplemental treatments are desirable in orchards where the curculio is more than ordinarily destructive.

LESSER APPLE WORM.[3]

The lesser apple worm as a rule is not noticeably injurious, except periodically in the Ozark Mountain regions and more occasionally in the New England and Middle Atlantic States. When abundant, however, the later generations in particular will frequently cause as much damage to the fruit as the codling moth.

This insect is closely related to the codling moth and, like it, feeds upon the flesh of the apple. The type of injury, however, is somewhat different, since the larvæ of the present species usually feed near the surface of the fruit, frequently excavating just beneath the skin (figs. 11 and 12.) In some instances, however, the larvæ penetrate deeper into the flesh, causing injury quite similar to that of the codling moth. The larvæ will attack any portion of the fruit but seem to prefer the calyx basin cavity, although entrance through the side is

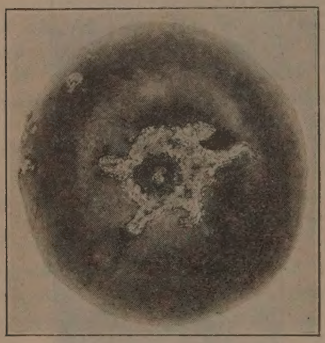

FIG. 11.—Work of lesser apple worm in calyx end of apple.

FIG. 12.—Injury to apple by lesser apple worm.

very common. The typical injury results in a blotch mine which is very conspicuous and unsightly. The lesser apple worm usually does not complete its feeding as early as does the codling moth, and, as a result, it is not infrequently found at work after the fruit has been barreled. The lesser apple worm is doubtless a native insect and has long been known to feed upon species of thorn apple, crab apple, and wild plum. It is primarily of economic importance as an apple pest, but has been reported on many of our common deciduous-tree fruits, as well as on black-knot of plum and galls of the oak and elm.

The life history and habits of the lesser apple worm are quite similar to those of the codling moth (see p. 3). The winter is passed in the larva stage within silken cocoons beneath the loose bark of fruit trees, in barrels or boxes which have contained infested fruit, in packing houses, or in almost any place accessible to the larvæ at the time they leave the fruit. When full grown the larva is about five-sixteenths of an inch in length, fusiform in shape, uniformly reddish or flesh colored above and lighter below, the head being brown to dark brown. The moths emerge in the spring about the same time as the codling moth and deposit their eggs upon the foliage. The moth is small, having dark colored front wings, with the basal one-fourth irregularly covered with rust red. The eggs are usually of an oval shape, slightly convex, covered with a network of ridges,

[3] *Laspeyresia prunivora* Walsh.

and have a diameter of about one-fortieth of an inch. When freshly laid the egg is of a pearly white color, resembling somewhat, except for its smaller size, that of the codling moth. The number of generations varies with the locality, there being a partial second generation in the North and as many as three and a partial fourth generation in the southern apple districts.

Since the life history and habits of the lesser apple worm are quite similar to those of the codling moth, thorough treatments as indicated for the latter (p. 6) will obviate the necessity of special control measures for this pest.

APPLE RED BUGS.[4]

Most orchardists are familiar with the manner in which the plum curculio (p. 7) and the rosy apple aphis (p. 22) dwarf and distort apples, but comparatively few fruit growers are well acquainted with the somewhat similar injuries caused by the so-called apple red bugs, which have attracted considerable attention in certain localities within the last decade. It is usually not difficult to distinguish the work of the red bug on the fruit from that of the plum curculio, but red-bug injury may sometimes be more readily confused with the work of the rosy apple aphis, although, upon a careful examination of the trees, the aphid-curled leaves surrounding the fruit would soon reveal whether the latter insect was responsible. Fruit injured by red bugs shows distinct depressions or dimples, while that attacked by the rosy apple aphis is more or less constricted and puckered about the calyx or blossom end. In many instances all three insects may be present in the same orchard, the combined attack causing the fruit to become very gnarled in appearance.

FIG. 13.—Apples deformed by apple red bugs. Note the dimpled appearance.

Shortly after hatching in the spring, the young red bugs or nymphs commence sucking out the juices of the new foliage, the injury causing the foliage to become somewhat distorted and covered with small reddish spots. Later, as the fruit develops, the insects turn their attention to it, stunting the growth as well as disfiguring it by the red-bug dimples (fig. 13). Severely attacked fruit will frequently fall to the ground, while that which is the least injured will remain on the tree until harvest. Late in the season the injured leaves have a very ragged and crinkled appearance similar to that shown in the illustration (fig. 14).

When abundant the apple red bugs become first-class orchard pests and frequently ruin the fruit for market purposes as quickly and thoroughly as any insect with which the fruit grower has to contend. Red bugs, it is believed, are native to this country and have been reported as occurring in the New England States and certain of the Middle Atlantic States, as well as in Michigan and Canada, and are undoubtedly present in many eastern States. While these insects are primarily apple pests, they are known to attack the pear and thorn apple.

[4] There are two species, the darker one, *Heterocordylus malinus* Reuter, known as the apple red bug, and *Lygidea mendax* Reuter, which is lighter in color and is called the false apple red bug.

Both species of the red bugs pass the winter in the egg stage, but the eggs are deposited in somewhat different places and hatch at slightly different periods. The eggs of the apple red bug are inserted in the bark of the smaller branches and are difficult to locate. They are about one-sixteenth of an inch long, curved, whitish in color, and they begin to hatch shortly after the leaves commence to unfold. The eggs of the false apple red bug are about the same size as those of the other species and are usually inserted in the lenticels of the small branches and commence to hatch about a week later than those of the other species. The young nymphs of each species are red, but those of the red bug become darker with age, approaching black when full grown, whereas those of the false red bug are relatively lighter in color throughout their nymphal period. The nymph of the red bug is about one-twentieth of an inch long when first hatched and approximately one-sixth of an inch long in the last nymphal stage, while that of the false red bug is slightly smaller in all of its nymphal stages. The feeding of the nymphs is confined to sucking of the juices from the foliage and fruit. During the latter part of the summer the insects reach maturity and deposit their eggs for the next generation, which do not hatch until the following spring. The adult apple red bug is about one-fourth of an inch in length, dark red to black in general color, with reddish wings which are usually black along the wing tips and have a black spot close to the outer edge. The false red bug (fig. 15) is about the same size as the other species, but is somewhat lighter in general color and has an orange red head and prothorax. The adults of both species are active in depositing eggs and when disturbed are very agile and endeavor to hide from view.

FIG. 14.—Appearance of apple leaves as a result of red bug injury.

Since the red bugs are sucking insects, they can best be killed by means of contact insecticides. Forty per cent nicotine sulphate is commonly used at the rate of one-half pint to 50 gallons of soapy water made by dissolving therein about 2 pounds of soap. If it is desired to use a combination spray for the control of sucking and chewing insects and fungous diseases, the same amount of nicotine sulphate (omitting the soap) may be combined with arsenate of lead and summer-strength lime-sulphur solution or Bordeaux mixture. The first application should be made during the pink cluster-bud stage and the second just after the petals have dropped, at which times commercial orchards are usually sprayed for other insect pests and fungous diseases. Attention should be called to the fact that the spraying should be done preferably on warm days when the nymphs are actively at work. It is also desirable to use a high-pressure driving spray and quickly wet the entire tree, and if feasible have two operators spray simultaneously from opposite sides of the trees, so that none of the insects will have a chance to escape by dodging the spray solution.

FIG. 15.—Adult of false apple red bug. Enlarged.

APPLE MAGGOT OR "RAILROAD WORM."[5]

The apple maggot, a native insect, is commonly found in the New England States and Canada and also occurs in Michigan and other Northern States. When abundant, it presents a very serious problem and is likely to cause considerable injury, particularly to the varieties most susceptible to attack. The work of this insect in its earlier larval stages is often very deceptive, and apples that appear sound externally are frequently infested with one or more maggots. As soon as the infested apples become mellow, however, the maggots develop rapidly and can be readily detected by the brownish tunnels which are often visible through the skin, especially with varieties having light or yellowish colored skins (fig. 16). The larvæ or maggots make winding burrows or tracks throughout the flesh of the fruit and often reduce it to a brown pomace-like consistency, rendering it absolutely worthless for market purposes (fig. 17).

The original food plant of this insect was the haw, but at present the cultivated apple is its principal economic host. Although there is a wide range of susceptibility among the several varieties of apples, usually the summer and fall sweet to subacid varieties are preferred, but in their absence the more acid, as well as the winter apples, are attacked as soon as they reach the proper state of maturity. In addition to the apple, this insect has been reported on pear, plum, cherry, huckleberry, blueberry, cranberry, mountain cranberry, and snowberry.

The apple maggot passes the winter in the pupa stage beneath the surface of the soil, the true pupa being developed within the puparium a few days after the latter is formed. The puparium (fig. 18) is at first light brown, later becomes darker, and is about three-sixteenths to one-fourth of an inch in length. The adults or flies first begin to issue during midsummer, usually in July, and deposit their eggs in the early varieties of apples, just beneath the skin of the fruit. The adult fly (fig. 19) is slightly smaller than the common house fly but is naturally somewhat sluggish unless disturbed, when it can dart quickly out of reach. The adult is shiny black in general color, the abdomen having four transverse white bands in the case of the female and three in the male, and the wings are marked with four irregular dark bands. The flies do not usually oviposit until a few weeks after emergence. The eggs are more or less yellowish white and average about one-thirtieth of an inch in length. They hatch in a few days and the resulting larvæ immediately begin to feed on the flesh of the fruit. After falling from the tree, the infested apples quickly mellow and shortly thereafter the full-grown larvæ leave the fruit and enter the ground. The larva (fig. 17) is whitish to yellowish white and when full grown measures about three-eighths of an inch in length.

In southern New England there is a small partial second generation, but the majority of the first brood do not transform to the adult stage until the following summer, and a small percentage remain in the ground until the second summer, thus making for the latter a two-year life cycle. The flies of the first brood emerge during midsummer, while those of the second brood issue during the fall and deposit their eggs in the different varieties of fruit when it reaches the proper stage of maturity.

The most practical method of reducing injury, though not as effective and dependable as desirable, is to spray the trees, beginning in early July, with arsenate of lead powder, using 1 pound, or 2 pounds of the paste, to each 50 gallons of water. From two to three applications made at intervals of about two to three weeks will be required. The flies are killed by lapping the poison from the foliage and fruit. The prompt picking up and destruction of the

[5] *Rhagoletis pomonella* Walsh.

FIG. 16.—Characteristic appearance of apple maggot tunnel as seen through skin of fruit.

FIG. 18.—Puparium of apple maggot. Enlarged.

FIG. 17.—Injured apple showing whitish apple maggot larva within.

FIG. 19.—Apple maggot flies resting on fruit. Slightly enlarged.

dropped fruit shortly after it falls, or pasturing hogs in the orchard, will serve to destroy the maggots before they have an opportunity to enter the ground. Another means of reducing the insect is to cultivate the orchard thoroughly during the early summer so as to kill the puparia before the flies begin to issue.

APPLE LEAF-ROLLER.[6]

About the time the apple buds are beginning to open in the spring the caterpillars of the apple leaf-roller begin to hatch and crawl to the buds, where they eat minute holes in the unexpanded leaves. They continue to feed upon the unfolding leaves, which they web together by means of silken strands. Later the larvæ roll up a single leaf or several leaves (fig. 20) and also web together and feed upon the blossom buds, often causing in this way considerable injury during the pre-blooming period. The caterpillars sometimes spin very heavy webs, as shown in figure 21. After the apples have set, the caterpillars frequently neglect the foliage for the fruit, upon which they feed, protected more or less by surrounding webbed-up leaves. They eat the apples voraciously, consuming irregular patches of the pulp (figs. 22 and 23) and have been known in instances of excessive abundance practically to destroy entire crops. They are especially destructive in portions of Colorado and New Mexico, where serious outbreaks have occurred, and more occasionally in New York State. At this time they are attracting considerable attention in the Pacific Northwest.

FIG. 20.—Leaf-roller injury to apple foliage.

The apple leaf-roller is a native species, widely distributed throughout the United States, feeding upon a large variety of plants, as apple, pear, quince, plum, cherry, apricot, currant, raspberry, gooseberry, and a large number of trees and shrubs, as well as many other agricultural crops.

The winter is passed in the egg stage (fig. 24), the eggs being laid in grayish masses of over 100 on the trunk, limbs, and branches of the trees. The full-grown caterpillar is about three-fourths of an inch in length, light green in color, with dark brown to black head. Upon reaching maturity the larva transforms to a brownish pupa, usually within a rolled-up leaf (fig. 25), and emerges in about 10 days as a moth (fig. 25), which deposits the overwintering eggs. The moth is small, with a wing expanse of about three-fourths of an inch, the forewings being cinnamon brown in color, with lighter markings.

[6] *Archips argyrospila* Walker.

FIG. 21.—Heavy silken web spun by apple leaf-roller larva on grapevine and arbor.

FIG. 23.—Leaf-roller injuries to apples often callus over as corky depressions.

FIG. 22.—Fruit eaten by apple leaf-roller larvæ.

FIG. 24. Egg mass of apple leaf-roller.

As the result of considerable experimentation it has been found that the apple leaf-roller is best controlled by destroying the eggs with a good miscible oil, used at the rate of 1 gallon to 15 gallons of water, applied during the dormant season, preferably just before the buds swell in the spring. The spraying should be done on bright days to insure as rapid evaporation of the oil as possible. In instances of severe infestations, an application of lead arsenate at the rate of 1½ pounds of the powder or 3 pounds of the paste to 50 gallons of water or fungicide should be made as soon as the larvæ begin hatching. There is also evidence that the addition of one-half pint of 40 per cent nicotine sulphate to each 50 gallons of spray is effective in destroying many of the newly hatched larvæ.

ROSE-CHAFER.[1]

Fruit growers are frequently alarmed by the discovery in their apple orchards during late May or early June of an invading horde of the rose-chafer, or "rose-bug," as it is sometimes called. These awkward, long-legged, yellowish brown beetles often skeletonize the foliage (figs. 26 and 27) and are particularly destructive to the fruit by eating out irregular holes, thus rendering it practically worthless (fig. 28). This insect appears every now and then in large numbers, especially in poorly cared for, untilled orchards, or in orchards adjacent to sandy, uncultivated land. Well-kept orchards, however, are sometimes seriously damaged, particularly in regions of light sandy soils, where the rose-chafer is more or less a chronic pest.

FIG. 25.—Apple leaf-roller cocoon, pupal skin, and moth. Enlarged.

It is found chiefly in the eastern part of the United States and as far west as Oklahoma and Colorado. The beetles are partial to the rose and grape, but will attack practically all kinds of vegetation, including fruit and shade trees, shrubs, vegetables, etc.

This insect passes the winter in the larva stage in an earthen cell beneath the surface of the soil. The full-grown larva is about three-fourths of an inch in length, yellowish white in color, with a light brown head, and transforms in the spring to a light brown pupa (figs. 29 and 30). The beetles (fig. 31), which are light yellowish brown and about one-third of an inch in length, with long, ungainly, spiny legs, appear early in the summer and feed upon the foliage and fruit, as described. The females deposit very small, white, oval eggs singly in the soil a few inches below the surface. The larvæ hatch in a couple of weeks and feed on decaying vegetation and on succulent roots, preferring those of the grasses. They reach maturity in the fall and then construct their small, earthen cells in which they hibernate.

It is very difficult to combat this pest successfully, particularly when it arrives in swarms, as is frequently the case. While no spray materials that have given entire satisfaction have been discovered, some measure of protection is afforded by one to two applications of arsenate of lead at the rate of 2 or 3 pounds of the powder, or 4 to 6 pounds of the paste, to 50 gallons of

[1] *Macrodactylus subspinosus* Fabricius.

FIG. 26.—Injury to apple foliage caused by rose-chafer. Leaves have dried and curled as a result of the attack.

FIG. 27.—Work of rose-chafer on apple leaf.

FIG. 29.—Pupa of rose-chafer, side view. Enlarged.

FIG. 30.—Pupa of rose-chafer, ventral view. Enlarged.

FIG. 28.—Apple eaten by rose-chafer.

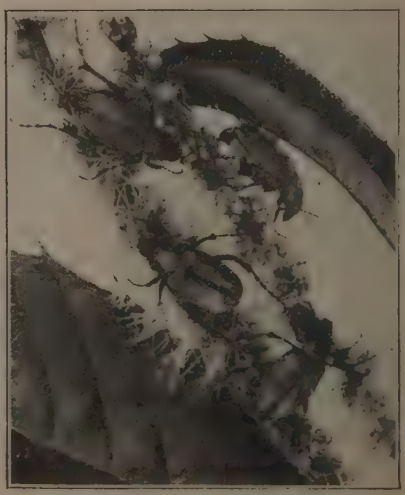

FIG. 31.—Rose-chafer beetles feeding on chestnut blossoms. Enlarged.

Bordeaux mixture (4–4–50), the first application being made as soon as the earliest beetles appear. Some success has also been reported from the use of arsenate of lead at the foregoing strength combined with 1 gallon of cheap-grade molasses to each 50 gallons of water. Self-boiled lime-sulphur mixture has been found quite effective against this insect in New Jersey and in addition would have some value as a fungicide.

In regions where this species is prevalent, the orchardist during the late spring should practice thorough cultivation, especially of sandy land, in which the insect thrives, so as to destroy the pupæ previous to their transformation to the beetle stage. The maintenance of meadows on sandy soils, in the neighborhood of orchards and vineyards, is bad practice from the standpoint of rose-chafer control.

APPLE CURCULIO.[8]

The apple curculio is a snout-beetle and attacks the apple usually in association with the plum curculio (p. 7). It is not nearly as abundant as the latter, but may occur in injurious numbers under conditions that are propitious to the plum curculio, as in weedy, uncultivated, unpruned orchards and in orchards adjacent to woodlands. It covers the same general territory as the plum curculio, being found in the States east of the Rocky Mountains. It has attracted most attention as an apple pest in the North-Central States. Among the more important food plants of the apple curculio are apple, pear, quince, crab apple, haws, etc.

Apples attacked by this beetle become dwarfed and gnarled (fig. 32) as they grow, and when severely punctured during their early development many drop to the ground, where some become sufficiently mellow to permit the larvæ to reach maturity. The egg-laying punctures of this insect differ from those of the plum curculio in that the female does not cut a crescent-shaped slit adjacent to the egg cavity. The apple curculio inserts its beak into the flesh of the fruit and, after enlarging the opening at the base, deposits an egg. It then plugs the hole with excrement (fig. 33).

In general the life history and habits of this insect are similar to those of its near relative, the plum curculio, except that the pupæ of the apple curculio (fig. 34) develop within the fallen fruit, whereas the pupæ of the plum curculio are formed in the soil. The full-grown larva (fig. 35) is a dirty white, curved, wrinkled, footless grub, having a light brown head. The small, reddish brown adult or beetle (fig. 36), measuring about one-fourth of an inch in length and having four conspicuous humps on its wing covers, eats very sparingly of the skin of the fruit while making its feeding and egg laying punctures, and hence poisoned sprays are of comparatively slight value in its control. The very minute, oval egg (fig. 37) is at first pearly white, but changes later to dull yellowish.

As stated, poison sprays are of little avail, though they may perhaps have some slight value as a deterrent. It is therefore necessary to rely chiefly upon orchard sanitation, such as pruning to admit sunlight and the removal of favorable hibernating quarters, such as trash and litter, from within or near the orchard. If the fallen fruit infested with larvæ or pupæ is exposed to strong sunlight, the insects will die, and it is mainly for this reason that the apple curculio is better held in check in well-pruned and cared for orchards. Where feasible, the prompt destruction of the fallen fruit or raking it out into the sunlight will help to keep this pest in check.

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[8] *Tachypterus quadrigibbus* Say.

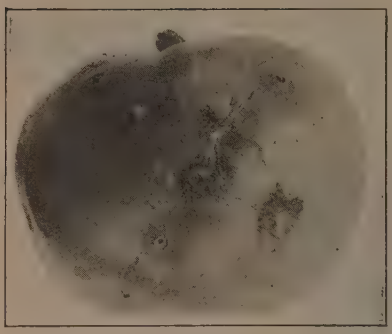

FIG. 32.—Apple showing punctures made by apple curculio.

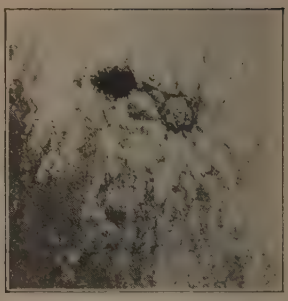

FIG. 33. Feeding puncture (left) and plugged egg cavity (right) of the apple curculio. Enlarged.

FIG. 34.—Live pupa of the apple curculio in natural position in apple. Enlarged.

FIG. 35.—Larvæ of the apple curculio. Enlarged.

FIG. 36.—Apple curculio beetle resting on apple. Slightly enlarged.

FIG. 37.—Egg puncture and egg of apple curculio in wild crab apple. Enlarged.

GREEN FRUITWORMS.[9]

Every now and then orchardists discover that some pest has eaten large holes in their young apples (fig. 38), but upon careful search are unable to find any trace of the destructive agent. In many instances injury of this character is due to one or more of the species of green fruitworms. It is fortunate that these caterpillars are not generally as abundant as some other fruit insects, since during their more or less sporadic outbreaks they often cause important injury. They not only attack the fruit, but previous to its formation the young larvæ eat the buds and foliage. These insects, of which there are numerous species, are widely disseminated in the United States and feed upon the apple, pear, and other common deciduous fruits, as well as many forest trees.

The life histories of the several species are somewhat similar, differing chiefly in that certain of them pass the winter in the moth stage, whereas the others hibernate as pupæ in the soil, either inclosed in thin, silken cocoons or as naked pupæ. The moths are about three-fourths of an inch long when at rest and resemble one another closely, having in general an ash gray color. They deposit circular-shaped pinkish eggs with a diameter of about one-fiftieth of an inch, in the scars of branches, particularly in leaf scars, the eggs usually being laid previous to the appearance of the leaves. The young larvæ hatch from these eggs and commence feeding upon the buds and expanding foliage and later attack the fruit as soon as it develops. Upon reaching maturity, certain species of larvæ are about 1½ inches long, yellowish green, with a slender, light-colored stripe down the middle of the back and a wider stripe along each side. At the conclusion of their feeding period they enter the soil and there construct the pupal cells, in which they transform successively to pupæ and moths. The pupæ are dark brown, a trifle over a half inch in length, and are to be found from 1 to 3 inches below the surface of the soil.

FIG. 38.—Two species of green fruitworms feeding on foliage and young apples.

An early application of arsenate of lead while the larvæ are small is the most practical method of control. This application may be made during the pink cluster-bud stage, with 2 pounds of the powder or 4 pounds of the paste to 50 gallons of water or fungicide. If no spray is applied until the fruit has set, the worms will have developed to such a size that only very strong doses of the arsenical will be of value, and in any event much of the fruit will be damaged before the poison will take effect.

RED-BANDED LEAF-ROLLER.[10]

During the harvest orchardists sometimes note apples injured by an insect that has eaten out small, shallow, somewhat irregular patches just through the skin (fig. 39), particularly where a leaf has been in contact with the fruit. Injury of this nature may be due to the small, active caterpillar of the red-banded leaf-roller, which is known to be quite widely distributed in the United

[9] *Xylina* spp.

[10] *Eulia velutinana* Walker.

States, occurring rather generally over the East and having also been reported from California and Texas. It is a very general feeder, attacking deciduous fruits, truck crops, flowers, shrubs, trees, etc., but only occasionally are its injuries to the apple very important, as during seasons of unusual abundance, or in orchards insufficiently sprayed.

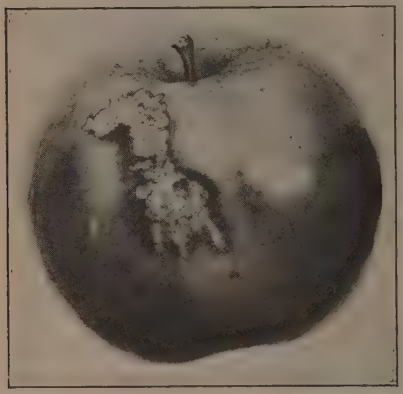

FIG. 39.—Injury to apple by red-banded leaf-roller.

The insect hibernates in the pupa stage, the pupa being less than half an inch in length and brownish in color. The moth emerges early in the spring and deposits its yellowish eggs in flat masses (fig. 40) on the twigs of the apple and other food plants. The moth is brownish with a wing expanse slightly over half an inch. Across the forewing of the female there is a relatively large dark red band. The full-grown larvæ are greenish and about three-fourths of an inch long. Two or three generations are thought to occur each year in the vicinity of Washington and probably only two farther north.

The usual orchard spraying schedule as recommended for the codling moth (p. 6) should hold this insect well in check.

SERPENTINE FRUIT-MINER.[11]

The larvæ of this minute moth make long, narrow, winding mines or trails just under the skin of the apple (fig. 41), greatly disfiguring it and lessening its keeping qualities. Thus far this insect, which has been called the serpentine fruit-miner, has not been sufficiently abundant to be the cause of much injury, though it is the subject of some inquiry, because of the unusual appearance of the injured fruit. Only recently has the adult been obtained and the exact identity of the miner determined. It is doubtless a native species and has been reported from Delaware, New York, Illinois, Oregon, and the Ozark Mountain regions. It apparently feeds only on the apple, though related species are miners on the twigs and branches of various plants. Little is known concerning its life history and habits, though it is supposed to winter in the larva stage. No experiments have been reported on methods of control of this species, as it has not been sufficiently important to necessitate careful study.

FIG. 40.—Egg mass of red-banded leaf-roller.

ROSY APHIS.[12]

The rosy aphis, a small, sucking insect, is unquestionably at the present time the most injurious of the plant-lice attacking the foliage and fruit of the apple. It causes annually an important loss. This aphis curls the foliage, especially that surrounding the fruit (fig. 42), and also attacks the fruit stems and the fruit. The latter often becomes dwarfed and distorted, resulting in the so-

[11] *Marmara pomonella* Busck. [12] *Anuraphis roseus* Baker.

called "aphis apples" (fig. 43). On young trees the aphids often feed upon the tender shoots, which frequently become twisted, sometimes making a complete loop. The rosy aphis is believed to have been introduced from Europe and is now commonly found in practically all of the apple districts of the United States. The only known food plants are the apple and its alternate summer hosts, the plantains.

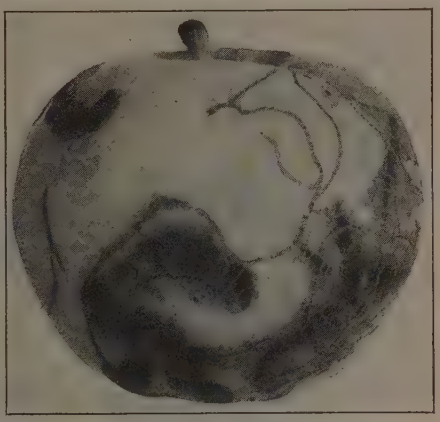

FIG. 41.—Work of the serpentine fruit-miner.

The winter is passed in the egg stage on the tree, and the so-called stem mothers begin to hatch about the time the buds burst and immediately settle upon the unfolding leaves. Several generations of the rosy aphis are produced on the apple and these feed upon the foliage and fruit as soon as it is formed, causing the leaves to become curled and deformed. Both winged and wingless individuals are produced, the former migrating when mature to the plantains. The wingless viviparous[a] female is rosy brown, becoming purplish with age, and is covered with a powdery bloom. The spring migrant is brownish green with black head and thorax and transparent wings. The abdomen has a large black patch on the center of the back and the appendages are partly black and partly yellowish brown. In the fall, migrants develop on the plantains and these return to the apple and produce sexual females, which deposit the overwintering eggs, usually on the twigs or in the axil of the buds and occasionally on the larger limbs or in the bark crevices. When first deposited the eggs are pale green, changing later to a glossy black.

FIG. 42.—Work of rosy apple aphis on fruit and foliage of the apple.

On account of its leaf-curling habits the rosy aphis is difficult to control. Best results can be obtained if a spray application is made in the spring period when the aphids are clustered on the green tips of the swelling buds. Where this aphid is usually troublesome the trees should be very thoroughly sprayed at this time with a contact insecticide, preferably 40 per cent nicotine sulphate at the rate of three-eighths of a pint to 50 gallons of water, to which should be added about 2 pounds of soap previously dissolved in hot water. If the San Jose or other scale insects requiring a dormant treatment are present, the orchardist may delay spraying for them until the proper time to treat the apple

[a] Viviparous females are those that bring forth young alive, the eggs developing and hatching within the body of the parent.

aphids and, if the nicotine sulphate is added to the lime-sulphur spray, there will be no necessity for making separate applications against scale insects and apple aphids. This combination treatment, popularly known as the "delayed dormant," consists of three-eighths of a pint of 40 per cent nicotine sulphate and about 6½ gallons of concentrated lime-sulphur (32° Baumé), with sufficient water to make a total of 50 gallons. *Soap should not be added to any solution containing lime-sulphur solution.* This spray should be applied when the bud tips show green and completed by the time the leaf tips have begun to separate. Orchardists with considerable acreage to treat, and planning to make the

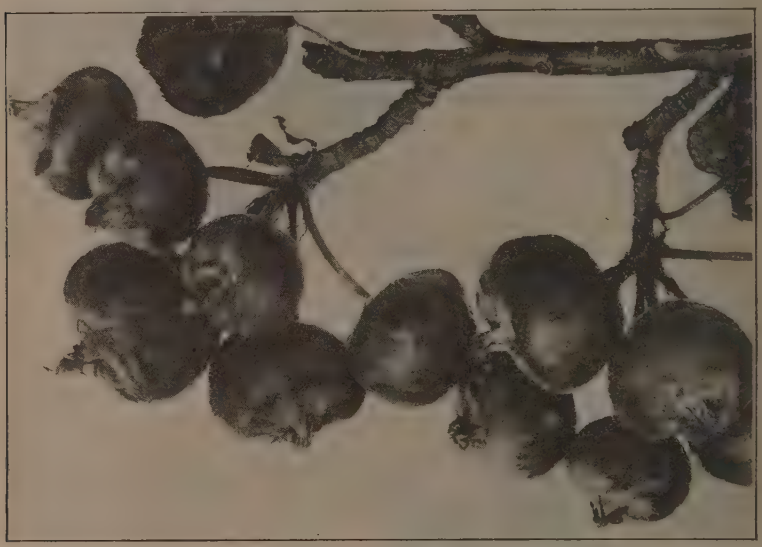

FIG. 43.—Apples injured and stunted by rosy apple aphis. Commonly called "aphis apples."

"delayed dormant" application, should be sure to have adequate equipment to accomplish the work before the foliage expands to any appreciable extent.

GREEN APPLE APHIS.[13]

The green apple aphis hatches from overwintering eggs in the spring about the same time as the rosy aphis, but unlike the latter feeds during the entire season upon the apple. It is often injurious to bearing orchards, but is much more serious as a nursery pest and in young orchards, sucking sap from the tender shoots and leaves (fig. 44), the latter becoming much curled, the attack materially checking the growth, especially during periods of drought. This insect secretes a large amount of honeydew on which ants feed; these often are quite abundant and are mistaken for the real depredator. A black fungus grows on the honeydew, giving the foliage and shoots a sootlike appearance. The green apple aphis is widely disseminated throughout the United States, feeding principally on the apple, but it has also been recorded upon the pear, wild crab, and white thorn.

[13] *Aphis pomi* DeGeer.

The insect passes the winter in the egg stage, the eggs being laid on twigs and water sprouts. They are yellowish green when freshly laid, later changing to a glossy black. The so-called stem-mothers hatch from these eggs about the time the buds begin to burst. From 9 to 17 generations are produced during the season, following which the sexual individuals appear and deposit the overwintering eggs. The wingless viviparous female is of a uniform green color, darkening with age, frequently having a yellowish head. The winged viviparous female is of a pea-green color, with head and thorax shiny black, wings transparent, and appendages more or less completely black.

FIG. 44.—Green apple aphis on apple foliage.

Thorough spraying of trees as the buds are bursting in the spring (delayed dormant treatment) as described for the rosy aphis (pp. 23–24) will be of much value in controlling this species. By midsummer, however, the aphids may become abundant again and in the case of young orchards do considerable damage in checking tree growth. It is a question of judgment on the part of the orchardist whether or not to spray, in view of the only partial effectiveness of treatments due to the curled and rolled-up leaves. If the injury is pronounced, spraying with the 40 per cent nicotine sulphate and soapy water spray is probably advisable, care being taken to apply the liquid thoroughly and with force.

FIG. 45. — Individuals of apple-grain aphis clustered on swollen apple bud. Enlarged.

APPLE-GRAIN APHIS.[14]

Fruit growers are often unnecessarily alarmed early in the spring upon finding the swollen apple buds covered with small, light-greenish aphids (fig. 45) awaiting an opportunity to feed upon the first succulent leaf tissue that appears. Later when the tree is in bloom, the same aphids may appear in hordes in the blossoms, often 15 or 20 individuals to a single flower. This is usually the apple-grain aphis, which, even when abundant, is believed to cause no important injury, since it leaves the apple shortly after the blooming period, migrating to grains and grasses, on which it passes the summer.

FIG. 46.—Eggs of apple-grain aphis on twig. Enlarged.

The apple-grain aphis, or "apple bud aphis," as it is sometimes called, is quite widely distributed throughout the United States. It passes the winter in the egg stage. The eggs (fig. 46), which are laid in crevices of the bark or on the twigs, are pale green when first deposited, later changing to a glossy black. Some of the eggs hatch prematurely during warm days in winter and are destroyed, but the majority do not hatch until the buds commence to swell. Several generations are produced by the time the apple blooms have fallen, at which time the aphids migrate

[14] *Rhopalosiphum prunifoliae* Fitch.

to grains and grasses, as described. The wingless viviparous female is pale green in color, darkening with age, and on its back are commonly found three longitudinal stripes of darker green. The appendages are marked with black near the tips. The winged viviparous female is greenish, with a glossy black head and thorax and with each side of the abdomen marked with a row of black dots and a small black patch near the base of each cornicle. The wings are transparent and the appendages are more or less completely black. In the fall migrants develop on the grains, and these return to the apple and produce the egg-laying females. After mating with the winged males the sexual females deposit their overwintering eggs.

FIG. 47.—Apple leaf, showing mottled appearance due to rose leafhopper.

If the apple-grain aphis is the only species present, it will cause but slight injury to the apple, and special control measures will not be required. In many instances, however, some of the other common and more injurious apple aphids are at work, in which event spraying with nicotine sulphate, as recommended for the rosy aphis (p. 23), will be desirable and will kill the plant-lice present, regardless of the species.

ROSE LEAFHOPPER.[15]

During midsummer and early fall the lower apple foliage is often more or less stippled or mottled with white (fig. 47). An examination of such leaves will usually reveal on the lower surface many small, active insects, the so-called rose leafhopper (fig. 48). During recent years injuries by this pest have attracted increasing attention in certain commercial orchards. Leaves seriously infested by this hopper are unable to function properly and in extreme cases fall to the ground, interfering with the proper development of fruit buds and fruit. The leaves are not curled by this species, such injury being caused by the apple leafhopper (p. 27).

The rose leafhopper is believed to have been introduced from Europe, perhaps on nursery stock, and is now widely distributed throughout the United States. Among its food plants, in addition to the rose and apple, are our common deciduous fruits; the grape, raspberry, currant, gooseberry, and blackberry; the elm, oak, etc. Rosaceous plants, however, are preferred.

The rose leafhopper passes the winter in the egg stage. The winter eggs are deposited beneath the bark of the apple and other plants, especially the rose where available, producing small, blister-like spots, slightly crescentic in outline. The egg is elongate, about one-fortieth of an inch in length, and at the time of deposition is transparent, changing toward the close of its incubation to yel-

[15] *Empoa rosae* Linnaeus.

lowish white. The young or nymphs hatch in the spring, usually from three to four weeks earlier than the apple leafhopper, and immediately begin their attack upon the foliage. They are full grown during early summer, at which time they are yellowish green and about one-eighth of an inch in length. After feeding on the foliage for several weeks the adults deposit eggs in the veins of the leaves. The second generation hatches from these eggs and the nymphs continue to feed upon the foliage. It is the work of this brood which as a rule is most conspicuous during late summer. The second brood of adults deposits the overwintering eggs in the bark of the apple, rose, etc., as previously mentioned.

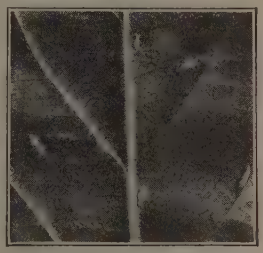

FIG. 48.—Rose leafhoppers on apple leaf.

For the control of the rose leafhopper 40 per cent nicotine sulphate should be used at the rate of 1 part to 1,200 or 1,500 parts of water. If other grades of nicotine compounds are employed, care should be taken that the diluted spray has an equivalent strength, namely, about 0.03 per cent of actual nicotine. Fish-oil or laundry soap should be added at the rate of 2 to 3 pounds to each 50 gallons of water. The spraying should be directed against the first-brood nymphs on the under surface of the lower leaves, which will require careful and thorough spraying. One application should so reduce the "hoppers" that further spraying will not be necessary. The treatment should be made when the first-brood nymphs are present in maximum numbers, and preferably in the first to third stages, which as a rule will be 3 to 4 weeks earlier than the first spray for the apple leafhopper. If spraying for the first brood has been neglected and the second brood requires treatment, use 40 per cent nicotine sulphate as described above, timing the application when the nymphs are present in maximum numbers.

FIG. 49.—Apple leaves curled by apple leafhopper.

APPLE LEAFHOPPER.[16]

The apple leafhopper much resembles in size and general appearance the rose leafhopper (p. 26), though its injuries are quite different. This form attacks principally the tender terminal leaves, causing them to become reduced in size, curled, and misshapen (fig. 49). The effect of feeding by the insects eventually causes the tips of the leaves to dry up and turn brown. This injury is often important on young orchard trees and on nursery stock. The

[16] *Empoasca mali* LeBaron.

apple leafhopper is widely disseminated throughout the United States, attacking numerous plants, including most deciduous fruits, as well as shade trees, grasses, cereals, truck crops, and the like.

The insect hibernates in the adult stage (fig. 50) beneath fallen leaves or other convenient shelter in the orchard or near by. It is pale green, about one-eighth of an inch in length, and on the thorax are two pearly white, longitudinal lines, connected by a transverse line forming the letter H. As the weather becomes warm in the spring the adults leave their hibernating quarters and make their way to the underside of the terminal leaves, where they commence feeding. Later the eggs are inserted beneath the lower epidermis of the leaf and in due time give rise to the nymphs. The latter are principally responsible for the curled and deformed condition of the foliage.

FIG. 50.—Adult apple leafhopper. Enlarged.

Three generations are produced each year in the Middle Atlantic States, the adults of the last one hibernating as described. The eggs are very minute, cylindrical, about one-thirtieth of an inch in length, transparent when first deposited, changing later to a pale yellow. In size the nymphs vary according to age and in general have a yellowish-green color. The adults are very active and when disturbed can readily dart from one limb to another or fly to near-by trees.

The apple leafhopper, like the rose leafhopper, can best be controlled by a nicotine spray, as 40 per cent nicotine sulphate, at the rate of 1 part to 1,200 or 1,500 parts of soapy water. The spraying should be done against the first-brood nymphs, special attention being given to covering the lower surface of the leaves, and the application made when the insects are mostly in the third nymphal stage. This can be determined by frequent examinations of the insects on the leaves. Since lime-sulphur is frequently used as a summer spray, the nicotine sulphate may be combined with it, *omitting, however, the soap.* Arsenate of lead, if desired, may be added to this combination and thus at the same time effect the control of chewing insects as well as of fungous diseases.

BUD MOTH.[17]

The little, brownish, overwintering caterpillars of this species are about half-grown when the apple buds begin to swell in the spring and are ready to gnaw into the buds when these open. Later they feed upon the expanding foliage (fig. 51, B), but the injury is usually greatest to fruit buds, which are frequently devoured to such an extent as to destroy the prospects of a crop. As mentioned later, injury of a different nature is caused during the summer and early fall by the new generation of larvæ, but this damage is not so serious as that produced by the overwintering caterpillars. Nursery stock is sometimes seriously injured and the pest often is accidentally distributed through the sale of the infested trees.

The bud moth was introduced into this country from Europe and easily ranks as the most important of the apple bud-infesting insects. It is essentially a

[17] *Tmetocera ocellana* Schiffermüller.

FIG. 51.—Bud moth: *A*, Twig with winter cocoon or hibernaculum in crotch at *a*; *B*, spring feeding of larva in expanding leaves; *C*, later stage of infested leaves, showing dead, rolled leaves; *D*, larval nests in rolled leaves, a deserted one at *b* and a new one at *c*; *E*, feeding areas and larva on a leaf; *F*, mature larva; *G*, *H*, pupal cocoons at *d* and *e*; *I*, pupa; *J*, *K*, bud moth adults; *L*, eggs on underside of leaf, enlarged; *M*, two leaves showing summer feeding of larva; *f*, appearance on upper surface; *g*, web-covered feeding area on under surface in which is partly concealed a tube of silk and frass; *N*, a common condition where two leaves are webbed together, one leaf being dead and detached from its base; *O*, *P*, diagrams of larva showing arrangement of tubercles and hairs, enlarged.

northern species, being found chiefly in the upper tier of States from coast to coast, but is perhaps most numerous in the New England States, where it frequently causes a considerable loss, particularly in unsprayed or poorly cared for orchards. The apple is its principal host, but it will also attack pear, quince, peach, cherry, plum, prune, blackberry, laurel, oak, and other plants.

FIG. 52.—Holes in apple made by bud moth larvæ during summer.

The bud moth, as above mentioned, passes the winter as a half-grown, dark-brown, black-headed larva, within a small silken case, known as a hibernaculum (fig. 51, A). This is composed of silk, reinforced by small bits of bark or leaves, and is attached to an apple twig. As soon as the bud scales commence to separate in the spring the larvæ begin feeding and continue to work on the expanding foliage and flower parts, usually webbing these more or less together by means of silken strands so as to form a protective covering. Some of the caterpillars continue their burrows through the buds into the tender twig growth. In early summer the caterpillars reach maturity, when they are reddish brown, with a black head, and are about half an inch in length. Subsequently they transform to pupæ within a curled leaf or several leaves sewed together. The pupa (fig. 51, I) is brownish and about five-sixteenths of an inch in length. The small ash-gray moths (fig. 51, J and K), having whitish bands across the forewings and a wing expanse of slightly more than half an inch, appear shortly afterwards and deposit very small, oval, practically transparent eggs (fig. 51, L), which hatch in a week or so following their deposition. The new generation of larvæ protect themselves with a covering of silk as they feed upon the foliage and often eat out shallow excavations through the skin of the fruit (fig. 52), particularly where it comes in contact with a leaf. These small holes may sometimes be confused with the so-called "stings" (p. 4) made by the late broods of the codling moth. As fall approaches the larva builds a hibernaculum, in which it spends the winter.

FIG. 53.—Apple bud infested with lesser bud moth larvæ. Enlarged.

Although it is somewhat difficult to effect immediate control in orchards where this pest is numerous, thorough spraying, regularly practiced, will soon bring satisfactory results. The first application should be made as soon as the flower buds appear, and this should be followed by another application when the buds are in the pink cluster-bud stage, using in each instance 2 pounds of arsenate of lead powder or 4 pounds of the paste to 50 gallons of water or fungicide. After the pest has been well reduced in numbers, the regular orchard sprays, as applied for apple scab, the plum curculio, and the codling moth, will ordinarily hold it in check. Where spraying is not so generally practiced, as in nurseries or young orchards, it will often be feasible to examine the trees and remove the infested leaves or else crush with the hands the insects within the nests.

LESSER BUD MOTH.[18]

Although the lesser bud moth is reported as an apple pest of minor importance, it is quite possible that its depredations are more extensive than generally recognized, since it may be responsible for a part of the injury usually attributed to the bud moth (p. 28). The overwintering larvæ bore into the buds as they begin to swell in the spring (fig. 53) and often, like the bud moth, destroy the flowering parts, thereby reducing the size of the fruit crop. As the leaves begin to expand, the larvæ tie them together with silken strands and feed within the inclosure thus formed. Another type of injury of much less importance is caused by the newly hatched larvæ mining in the leaves during midsummer (fig. 54).

FIG. 54.—Work of lesser bud moth larvæ on apple leaf.

The lesser bud moth is of European origin and was probably accidentally introduced into this country on nursery stock. Its present distribution covers the Northeastern and North-Central States. The pear is reported as its favorite food plant, but it has also been found on the apple, peach, plum, cherry, wild plum, and hawthorn.

At the conclusion of the spring feeding period, the full-grown larvæ, which are about three-eighths of an inch in length and of a brown to light green color, crawl to the tree trunk, where they spin cocoons beneath the bark scales or in crevices. The larvæ soon transform to pupæ which measure about three-sixteenths of an inch in length and vary in color at first from green to greenish brown, later changing to brown. The small moths (fig. 55), which have a wing expanse of about half an inch, are streaked in appearance and have conspicuous black and white banded legs. They deposit their small, yellowish colored eggs on the underside of the foliage, and the larvæ, upon hatching, eat through the lower epidermis of the leaf and mine therein until the approach of cold weather, when they desert their mines and spin their winter hibernacula.

FIG. 55.—Adult of the lesser bud moth resting on bark of pear tree. Enlarged.

The lesser bud moth can be well controlled by spraying the dormant trees with concentrated lime-sulphur solution, testing 32° Baumé, at the rate of 6 to 6½ gallons, diluted with sufficient water to make a total of 50 gallons—a strength also effective against the San Jose scale, blister mite, etc. If the orchardist does not wish to make the foregoing dormant treatment, two applications of arsenate of lead at the rate of 1 pound of the powder or 2 pounds of the paste to 50 gallons of water or fungicide may be substituted. The first of these applications should be made when the buds are swelling and the second as soon as the cluster buds have separated, commonly known as the pink cluster-bud stage.

[18] *Recurvaria nanella* Hübner.

NEW YORK WEEVIL.[19]

The large snout-beetle known as the New York weevil is more formidable in appearance than the plum and apple curculios, but is of less importance. It seldom attracts much attention, except locally during seasons of unusual abundance. While known to occur in many fruit districts, its injuries have been confined mainly to parts of the South and the Mississippi Valley. The New York weevil feeds upon a wide variety of host plants, the more important including our common deciduous tree fruits, white and burr oak, hickory, etc.

This weevil attacks the buds early in the spring and frequently eats into the twigs and tender shoots and cuts off the leaves. Occasionally young trees and nursery stock are quite seriously injured.

Although the life history of this beetle has not been carefully investigated, it is known that the adults are active early in the spring and attack the buds as soon as they start to push out. The adult is a large snout-beetle, about five-eighths of an inch in length and of an ash gray color, with small, light dots on the wing covers (fig. 56). The eggs are deposited on burr oak and certain other trees and the resulting larvæ live in the twigs. The larva is footless and light yellow, with yellowish brown head.

FIG. 56.—The New York weevil. Enlarged.

As a means of combating this insect, jarring similar to that done against the plum curculio is sometimes practiced. On small trees hand picking is advantageous if the number of trees is not too great. Probably a thorough application of Bordeaux mixture and arsenate of lead made as soon as the beetles appear would serve to repel or kill them before they seriously injure the buds.

RED-LEGGED FLEA-BEETLE.[20]

The red-legged flea-beetle every now and then appears suddenly in such numbers as to cause much alarm among orchardists who have set out young fruit trees on newly cleared locust land or in the vicinity of recently cut-over locust timber. While these sporadic attacks are often of a serious nature locally, they are fortunately of quite irregular occurrence. The beetles attack the buds early in the spring, resulting at times in the death of the trees. They also feed later upon the foliage and blossoms. The red-legged flea-beetle is found in Europe and the United States and is known to have a large number of host plants, the more important of which include the apple and other deciduous tree fruits, many small fruits, and such trees as locust, hazel, dogwood, etc.

The life history of this insect has not been fully investigated, but it is known that it hibernates in the adult stage. The beetles are about one-tenth of an inch in length, oblong-oval, with wing covers usually of a polished bright blue and bright red legs. The larvæ are supposed to live on the roots of locust.

The buds of fruit trees should be sprayed with arsenate of lead at the rate of 1½ to 2 pounds of the powder or 3 to 4 pounds of the paste to 50 gallons of water or fungicide, and the application repeated if the beetles continue their attack. Bordeaux mixture (4–4–50) serves more or less as a repellent, and this, combined with arsenate of lead, is as satisfactory a spray as anything known at the present time. As a supplementary control measure, the beetles should be jarred from the trees on sheets, as is sometimes done in the case of the plum curculio.

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[19] *Ithycerus noveboracensis* Förster. [20] *Crepidodera ruficpes* Linnæus.

APPLE FLEA-BEETLES.[21]

The so-called apple flea-beetles, in common with other flea-beetles, have strongly developed hind legs with which they are able to jump somewhat after the manner of fleas. Generally speaking, the two species here treated are not particularly destructive to bearing apple orchards, but young orchards and nurseries may sometimes be attacked so severely that special remedial measures are desirable. The overwintering beetles begin their attack upon the foliage in late spring to early summer, and when abundant eat many small holes through the leaves, giving them a perforated appearance. The larvæ appear during midsummer and feed upon the soft leaf tissue, skeletonizing the foliage.

The life histories of these insects have not been studied in detail. They pass the winter as bright, metallic green beetles, about one-sixteenth of an inch long. The eggs are yellowish, more or less elongate in outline, and are about one-twenty-fifth of an inch in length. The full-grown larvæ are generally black in color, about one-fourth of an inch long, and when grown pupate in fragile earthen cells just below the surface of the ground. Later the beetles issue and hibernate, there being but one generation annually.

Since flea-beetles are chewing insects, they may be controlled by an application of arsenate of lead of the usual strength in water or fungicide, as lime-sulphur solution or Bordeaux mixture. The application should be made as soon as the beetles are discovered. Orchards and nurseries properly sprayed for other chewing insects will seldom require special treatment for this pest.

SPRING CANKERWORM.[22]

Cankerworms, also known as measuring worms, loopers, or spanworms, have long been known as defoliators of apple and certain shade trees, and during cankerworm years may cause very important injury, especially in orchards not usually plowed or sprayed. In common with many other insects, cankerworms have their periods of abundance, usually lasting 4 or 5 years, after which they practically disappear, due to the combined effects of parasites, climate, etc. The damage is done by the larvæ feeding upon the foliage, which they consume, except the midribs and larger veins (fig. 57). By the close of the feeding period, orchards may be so defoliated that from a distance they appear brown and scorched as if swept by fire (fig. 58). Cankerworms are most often troublesome in neglected orchards and on unsprayed trees growing in sod around the home, and when once established under such conditions may defoliate the trees several years in succession.

The spring cankerworm is native to North America, occurring in Canada and the northern United States, ranging southward through the Mississippi Valley and westward to Kansas and Texas. It is present also in California. Its principal host plants are the apple and elm, although it also feeds on cherry, plum, prune, apricot, linden, etc. The winter is passed in the pupa stage (fig. 59) just below the surface of the ground. If the weather conditions are warm the moths will sometimes emerge as early as February, but, as a rule, emergence does not take place until early spring. The wings of the female moths are very much dwarfed and are useless for flying, and this necessitates their crawling up the trees in order to deposit their eggs. These are laid in patches along the trunk or larger limbs or in any convenient crevice. The females (fig. 60) are grayish, with a dark stripe upon the back, and measure about five-sixteenths of

[21] *Altica foliacea* LeConte; *Altica punctipennis* LeConte. [22] *Paleacrita vernata* Peck.

FIG. 57.—Work of the spring cankerworm.

FIG. 58.—Apple tree defoliated by spring cankerworm.

FIG. 59.—Two views of pupa of spring cankerworm. Enlarged.

FIG. 60.—Female moths of the spring cankerworm. Enlarged.

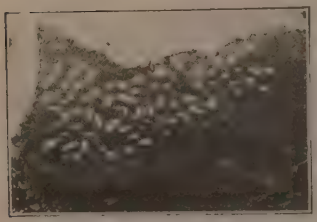

FIG. 61. Eggs of spring cankerworm on bark. Enlarged.

an inch in length. The male moth has dark gray forewings, which are crossed with three dark bands. On the back of the abdomen of both the male and female are several rows of reddish spines by which this species may be distinguished from the fall cankerworm. The eggs (fig. 61) are considerably less than one thirty-second of an inch in length, oval in shape, and yellowish green, sometimes showing a purplish iridescence. The young larvæ hatch about the time the foliage of the apple commences to appear and immediately start feeding. The growth is completed by late spring, when the larvæ usually lower themselves to the ground by means of a silken thread. The full-grown larva (fig. 62) is slender, about an inch long, varying in color from yellowish brown to black. There are often three broken yellow stripes above the spiracles, a narrow yellow stripe below the spiracles, and a broad greenish-yellow stripe along the lower surface, bordered on each side with black. There are only two pairs of prolegs, which necessitates the larvæ looping as they crawl, after the manner of measuring worms.

As already stated, orchards properly sprayed for the codling moth and leaf-eating insects are rarely if ever injured by cankerworms. Both the spring and fall cankerworms are controlled by thorough spraying of the trees with arsenate of lead at the usual strength, though if the caterpillars are half-grown or larger when the application is made, the quantity of arsenate of lead should be increased. Trees may also be protected by means of bands of sticky material or bands of cotton batting (see pp. 84–85) placed around the trunk a month or two previous to the time the buds usually begin to swell. These barriers will keep the females from crawling up the trees to deposit eggs and will, if properly applied, prevent the young larvæ that may hatch below the bands from ascending the trees. Thorough plowing and cultivation of the soil after the larvæ have pupated in late spring will be effective in destroying many of the insects while in this helpless stage.

FIG. 62.—Larvæ of the spring cankerworm. Enlarged.

FALL CANKERWORM.[23]

The caterpillars of the fall cankerworm, known also as loopers, measuring-worms, or spanworms, attack the foliage of the apple in the manner described for the spring cankerworm, and the two species, along with certain other loopers, may often be present on the trees at the same time. The fall cankerworm is a more general feeder than the spring form, attacking, in addition to the principal pome and stone fruits (fig. 63), the hackberry, common hickory, linden, walnut, butternut, etc. It occurs generally over the northeastern United States and in Canada, extending westward to the Central States. It is also present in California, attacking various deciduous fruits.

The life history of the present species differs somewhat from that of the spring cankerworm in that the winter is passed chiefly in the egg stage, the eggs being deposited usually in the fall, though some eggs are laid in the spring by moths that emerge at this time. The dark gray eggs, which are arranged neatly side

[23] *Alsophila pometaria* Harris.

FIG. 63.—Injury to cherry by fall cankerworm.

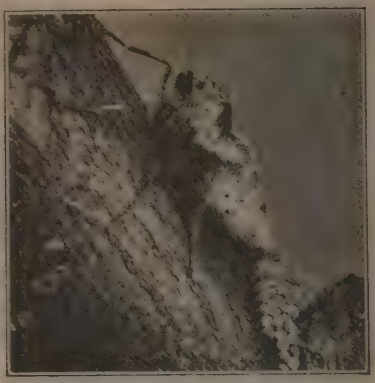

FIG. 66.—Female moth of the fall cankerworm depositing eggs. Enlarged.

FIG. 64.—Egg mass of the fall cankerworm. Enlarged.

FIG. 67.—Female moths of the fall cankerworm. Enlarged.

FIG. 68.—Male moth of the fall cankerworm. Enlarged.

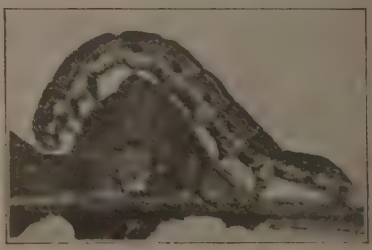

FIG. 65.—Fall cankerworm larva. Enlarged.

by side in clusters of 100 to 400 upon apple twigs, as shown in figure 64, resemble tiny flowerpots. When full grown the larva is about 1 inch in length, slender, with three pairs of prolegs, which serve readily to distinguish it from the spring cankerworm, which has only two pairs. The larvæ (fig. 65) are usually dark greenish or blackish in color, the majority showing on each side a prominent, longitudinal stripe of light lemon yellow. Like the moth of the spring form, females of this species are wingless and must crawl up the trees in order to deposit eggs on the twigs (fig. 66). The female moths (fig. 67) are dark gray and about half an inch long. The males (fig. 68) resemble in size those of the spring cankerworm and have about the same wing expanse. Neither sex, however, has the two rows of spines on the back of the abdomen, as has the preceding species.

The remedial measures indicated for the control of the spring cankerworm will be effective in combating the fall form. If bands of sticky material or cotton (see pp. 84–85) are used, they should be applied in October and kept in good order by frequent examination until the danger of injury is over in the spring.

APPLE-TREE TENT CATERPILLAR.[24]

The apple-tree tent caterpillar constructs the unsightly tents or webs, familiar objects in the spring in neglected orchards and in trees along fences, roadways, streams, etc. During caterpillar years considerable damage frequently results from defoliation to young orchards and trees not regularly sprayed. It is a native insect and occurs westward to the Rocky Mountains. On the Pacific slope it is replaced by other closely related forms. The favorite host plant of the tent caterpillar appears to be wild cherry, though it feeds freely upon apple, peach, plum, and other deciduous fruits, and upon various shade and forest trees.

The tent caterpillar passes the winter in the egg stage. The eggs are laid on twigs in clusters of 300 to 400 (fig. 69), each egg mass being covered with a waterproof material. An individual egg is somewhat thimble-shaped and is about one twenty-fifth of an inch in length. The eggs hatch as the apple buds begin to open or somewhat earlier and the larvæ are ready to attack the new leaves as soon as they appear. Almost immediately after hatching the colony begins to form its silken nest or tent, usually in the crotch of the tree limbs, sometimes at or near the trunk of the tree. As the larvæ grow, the tent is enlarged from time to time to accommodate the needs of the colony (fig. 70). When full grown, the caterpillars make their way to sheltered places for spinning their cocoons, in which the pupa stage is passed. The full-grown larva (fig. 71) is about 2 inches long, deep black with a white stripe along the back and blue and white spots on each side. The caterpillars are partially covered with yellowish hairs. The brownish pupa (fig. 72), which measures about three-fourths of an inch in length, is inclosed in a silken cocoon (fig. 72), loosely woven on the outside but tightly woven within, and, when freshly made, is more or less covered with a yellowish powder. The moths issue during midsummer and soon thereafter deposit their characteristic overwintering egg masses. The moths are reddish-brown, the forewings having two transverse, oblique, whitish stripes (fig. 73).

Apple orchards regularly sprayed for other insects will rarely be seriously troubled by this insect. The arsenate of lead used in the pink cluster-bud spray will destroy the caterpillars before they have occasioned much damage. Whenever it is desirable to spray for the tent caterpillars alone, arsenate of lead is advised in water or fungicide, using the poison at the rate of 1 pound of the

[24] *Malacosoma americana* Fabricius.

FIG. 69. — Two egg masses of the apple-tree tent caterpillar.

FIG. 70.—Larvæ and nest of apple-tree tent caterpillar in wild cherry tree.

FIG. 72.—Cocoon (left) and pupa (right) of apple-tree tent caterpillar. Enlarged.

FIG. 71.—Larva of apple-tree tent caterpillar. Enlarged.

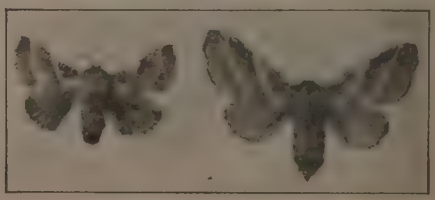

FIG. 73.—Apple-tree tent caterpillar moths: Male at left and female at right.

powder or 2 pounds of the paste to 50 gallons for the young caterpillars, but doubling the amount of poison in case the larvæ are one-third grown or over. It is quite practicable to destroy the nests and caterpillars by hand where these are not too numerous. During the work of pruning, lookout should be kept for the egg masses and these removed and destroyed. The destruction of wild-cherry trees in the vicinity of orchards will aid in keeping the pest reduced.

FALL WEBWORM.[25]

As the name indicates, the larvæ of this species web together a considerable number of leaves and twigs into an unsightly nest (fig. 74), much in evidence in the late summer and early fall. Within the nest the larvæ feed upon the leaves, as well as any fruit which may be inclosed. This insect is not ordinarily an important apple pest, except in epidemic years in neglected orchards or in young orchards to which arsenical sprays are not as a rule applied. It is a native species, widely distributed over the United States, and attacks a large variety of food plants, as the apple, pear, pecan, and various nut and shade trees. It is rather chronically injurious to shade trees.

The winter is passed in the pupa stage concealed beneath trash on the ground or just under the surface of the soil or sometimes in crevices of the bark. The dark-brown pupa (fig. 75) is inclosed in a flimsy silken cocoon, into which hairs from the caterpillar are woven. The first brood of moths issue irregularly, but some larval webs are to be found within a few weeks after the foliage has pushed out. In the Middle and Southern States a second brood appears in late summer or fall. The moths (fig. 76) have a wing expanse of about 1¼ inches and are variable in color, some being pure white, while others are white spotted with black and brown dots. The eggs (fig. 77), which are light yellow and globular, are deposited on both the upper and lower surfaces of the leaves in flat clusters, usually containing a few hundred eggs and are more or less covered with white hairs from the body of the female. Upon hatching, the caterpillars attack the terminal leaves of the branch and soon inclose a section within a silken web, enlarging it as more food is required. Feeding is continued within this web until the larvæ are nearly grown, when they frequently feed outside of the nest at night. A full-grown caterpillar (fig. 78) is about 1¼ inches long, with a broad, dark band along the back, the body being covered with long, whitish hairs, though there is a considerable variation in their color and appearance.

This species yields readily to arsenicals of the strength usually employed and will require no attention in apple orchards receiving the proper spray applications for other chewing insects.

RED-HUMPED APPLE CATERPILLAR.[26]

Ordinarily the red-humped apple caterpillar is one of the minor insect enemies of the apple, the injury consisting in the defoliation of individual branches or occasionally of young trees. The caterpillars feed in colonies at the ends of branches and are met with from midsummer until early fall, according to latitude. It is a native species, quite generally distributed throughout the United States, and, in addition to the apple, feeds upon the pear, cherry, plum, and prune, as well as certain other fruit, nut, and shade trees. As a rule it winters in the larva stage within a loosely constructed cocoon in some sheltered place on or near the ground (fig. 79, F). In the late spring or early

[25] *Hyphantria cunea* Drury. [26] *Schizura concinna* Smith and Abbot.

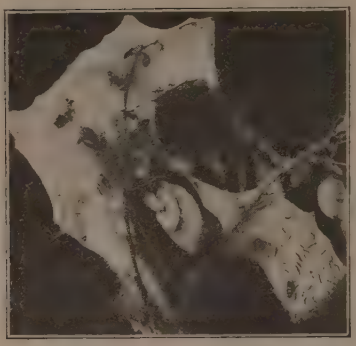

FIG. 74.—Nest or web of the fall webworm.

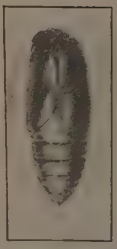

FIG. 75.—Fall webworm pupa. Enlarged.

FIG. 76.—Moth of fall webworm depositing eggs. Enlarged.

FIG. 77.—Eggs of fall webworm. Greatly enlarged.

FIG. 78.—Fall webworm caterpillars.

FIG. 79.—Red-humped apple caterpillar: *A*, Moth at rest on twig; *B*, moth with wings spread; *C*, apple leaf showing unhatched eggs at *a*, and young caterpillars feeding on lower epidermis at *b*; *D*, caterpillar nearly full grown; *E*, full-grown caterpillar; *F*, cocoons on ground amongst grass and dead leaves, one cocoon cut open to show caterpillar within.

summer the larvæ transform to pupæ, from which moths issue somewhat later. The parent moth is dark brown (fig. 79, B), with a wing expanse of about 1¼ inches. The forewings are grayish near the tips, merging into a dark brown near the body. The whitish, globular eggs (fig. 79, C) are deposited side by side in a cluster of 50 to 100 on the underside of the leaf. The young larvæ upon hatching are gregarious; they feed upon the lower leaf surface and eat out the soft parenchyma (fig. 79, C). As they become older they feed along the edges of the leaf (fig. 79, E), consuming the leaf more or less completely. Upon attaining their full growth the larvæ construct cocoons for the winter in the North, whereas in the South they spin very light cocoons in leaves or other convenient places, pupate, and finally transform to the adult stage, giving rise to a second generation. A full-grown larva (fig. 79, E) is about 1¾ inches in length, with the head coral red and a red hump on the fourth body segment. There are black and yellowish-white lines along the body, while on the back are two rows of blackish spines. When at rest the rear end of the body is elevated.

FIG. 80.—Egg mass of yellow-necked apple caterpillar.

The red-humped apple caterpillar will readily yield to arsenate of lead sprayed upon the infested trees. Where this insect has been more or less troublesome in past years, a lookout should be kept for its first appearance and the arsenical applied promptly. Scattering colonies, if not too numerous, can often be economically destroyed by hand.

FIG. 81.—Yellow-necked apple caterpillars.

YELLOW-NECKED APPLE CATERPILLAR.[27]

The yellow-necked apple caterpillar is very similar in its habits and method of feeding to the red-humped apple caterpillar, the injury as a rule being confined to individual limbs, although sometimes entire trees are defoliated, principally in young orchards. Ordinarily it does very little damage, except during occasional years. It is native to America and attracts attention principally in the Central and Northern States. It feeds upon the apple, pear, cherry, quince, and many nut and shade trees.

The insect passes the winter in the ground near the surface of the soil as a naked, brownish, pupa slightly less than an inch in length. The moths appear in midsummer and deposit some 25 to 100 eggs in flat masses (fig. 80) on the underside of the leaves. The adult, which has a wing expanse of about 2 inches, is reddish brown, with the forewings crossed by three or four dark lines. The larvæ feed in dense

[27] *Datana ministra* Drury.

colonies, at first on the lower surface of the foliage, but later on the edges of the leaves. If disturbed, they are likely to cease feeding and erect their heads and rear ends in a characteristic attitude, as shown in figure 81.

FIG. 82. Gipsy moth caterpillar.

Upon reaching their full growth the caterpillars leave the trees and enter the soil, where they pupate for the winter, there being but one brood each year. The mature larva measures about 2 inches in length. The head is black and the sides are striped with black and yellow lines; the body is more or less covered with whitish hairs.

When this species becomes troublesome on apple, it may be readily controlled by spraying the trees with arsenate of lead at the usual strength. Occasional colonies of the caterpillars found in the orchard can be shaken or brushed from the trees and killed on the ground.

GIPSY MOTH.[28]

The gipsy moth in its area of distribution is often quite injurious to the apple. The larvæ when young eat small holes in the leaves, but later consume the entire leaf with the exception of the larger veins. This insect is notorious for its injuries to shade and forest trees in the New England States, where large sums of money have been spent in restricting its further spread. It was accidentally introduced from Europe into Massachusetts about 1869. It is still confined to the New England States, except for an outbreak recently found in New Jersey. The caterpillars attack a very large variety of plants, including various deciduous fruits, but, as above mentioned, are especially destructive to forest and shade trees.

During the winter season the gipsy moth is in the egg stage, the eggs being laid in more or less flat masses, containing from 400 to 500 eggs and covered by hairs from the body of the female. These masses are placed frequently at the base of trees, under stone walls, or on wooden fences, the moth apparently not being particular, except to find a somewhat protected location. The caterpillars are hatching in the spring by the time the apple buds begin to show green, and as the leaves expand these are fed upon until the caterpillars complete their growth. The mature larva is about 2 inches in length, with characteristic markings on the back which consist of five pairs of blue tubercles followed by six pairs that are reddish in color. Between these markings is a thin yellow stripe, and the body is well clothed with black hairs (fig. 82).

FIG. 83.—Male gipsy moth.

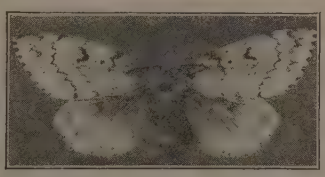

FIG. 84.—Female gipsy moth.

[28] *Porthetria dispar* Linnaeus.

The pupa measures about an inch in length and is of a dark brown color. The moths emerge during midsummer and deposit the overwintering eggs, there being but one brood of caterpillars each year. The extended wings of the male moth measure about 1½ inches from tip to tip, are light brown, and crossed with four irregular, dark lines (fig. 83). The female (fig. 84) is somewhat larger and is unable to fly. Its wings are whitish with dark lines on the forewings as in the male moth.

Orchardists can reduce the infestation to a considerable extent by examining their trees and surrounding fences for the egg masses during the winter and treating them with crude coal-tar creosote, to which should be added a small quantity of lampblack to serve as a marker. The trees should also be sprayed as soon as the leaves are large enough to take an application of poison. Since the gipsy-moth caterpillars are quite resistant to arsenical poisons, it is necessary to use 3 or 4 pounds of the arsenate of lead powder, or double this amount of the paste, to each 50 gallons of water or fungicide, and this strength is effective only during the very early season, when the larvæ are young.

BROWN-TAIL MOTH.[29]

Early in the spring, as the leaves are pushing out, the small larvæ of the brown-tail moth emerge from their winter nests and attack the foliage. Somewhat later in the spring they also feed upon the blossoms (fig. 85). When abundant they defoliate the trees more or less completely. The insect occurs rather generally over the New England States and extends into Canada. While not now especially destructive, it has in recent years been a pest of importance and may reappear in destructive numbers at any time. The brown-tail moth is a native of Europe and is thought to have gained entrance into this country about 1890 or a few years later. The apple is one of its favorite food plants, as is also the pear, but it is preeminently an enemy of shade and forest trees, except conifers.

The insects winter as very small caterpillars in tough silken nests composed of partly skeletonized leaves, securely webbed together (fig. 86). With the approach of warm weather the caterpillars emerge from their winter nests to attack the developing foliage. They continue feeding until early summer, when they become full grown, and spin very light cocoons, frequently in a leaf or amongst trash near the trees. The full-grown larva is about 1½ inches long and dark brown to black. The body is covered with reddish brown hairs and on each side is a row of white tufts, with two bright red tubercles near the posterior end of the body. The larvæ transform into dark brown pupæ about three-quarters of an inch in length and later the adults or moths appear. The adults (fig. 87) have white wings which expand about 1½ inches. The abdomen is tipped with a tuft of brown hairs, more noticeable in the female than in the male, which gives the insect its common name. The globular eggs are deposited on the underside of the terminal leaves, in clusters of from 100 to 300 eggs, the entire mass being covered with brownish hairs from the abdomen of the female. The eggs hatch in the latter part of summer and the young larvæ feed upon leaves for a time and later construct their winter nests on the terminal twigs, often quite conspicuous during winter (fig. 88). In figure 89 is shown a nest attached to apples.

There are two principal means of protecting trees from the ravages of the brown-tail moth. The first is to spray the trees, just as the larvæ are hatching, with arsenate of lead at the rate of 2 pounds of the powder or 4 pounds of the paste to each 50 gallons of water or fungicide. Particular attention should be given to applying the poison to the tips of all the branches, since the cater-

[29] *Euproctis chrysorrhœa* Linnaeus.

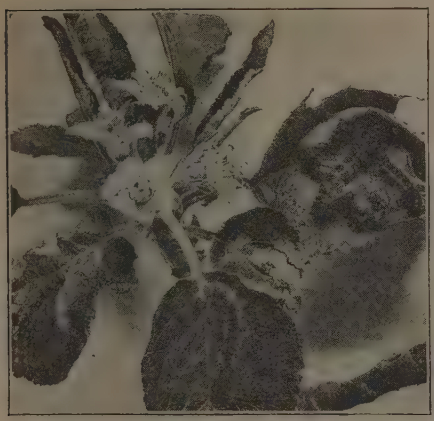

FIG. 85.—Brown-tail moth caterpillars devouring apple foliage and blossoms.

FIG. 86.—Two nests of the brown-tail moth.

FIG. 87.—Brown-tail moth: Male above, female below.

FIG. 88.—Nests of the brown-tail moth on apple tree.

FIG. 89.—Nest of brown-tail moth attached to apples.

pillars feed on the terminal leaves. The second or supplementary means of control is to remove and burn during the winter all of the brown-tail nests found on the trees. If the caterpillars' nests have not been destroyed during the winter or by the time the new foliage appears, the arsenate of lead treatment should be made promptly as described.

WHITE-MARKED TUSSOCK MOTH.[30]

During some years the white-marked tussock moth is of considerable importance by reason of its injuries to the apple, and at these times it is usually abundant on shade trees in the same region. Its injury consists in eating the foliage, though it has been known to do material damage by eating holes in the green fruit (fig. 90). It is a native species occurring quite generally throughout the eastern portions of the United States and in Canada. The caterpillars feed upon a very large list of plants, including the apple, pear, and other deciduous fruits, as well as a large number of shade trees. They are likely to be met with any year in orchards, but only occasionally do they cause serious damage.

The winter is passed as eggs, which are deposited in clusters containing from a few to several hundred and are protected by a white, frothlike substance (fig. 91). An individual egg is roundish and light cream-colored and the masses are placed upon the trunk, in crotches of limbs, and other places, usually upon the cocoon from which the female moth has emerged. The female moth (fig. 91) is light gray, with mere rudiments of wings, whereas the male has well-developed wings and is grayish, the forewings being crossed by irregular dark bands, with a white spot near the tip of the outer edge (fig. 92). The larvæ hatch in the spring after the foliage has appeared and with a few weeks of feeding attain full growth and seek a place upon the tree or on some near-by object to spin their cocoons preparatory to pupation. The larvæ are rather ornate, and when full grown measure about 1½ inches long (fig. 93). The head is coral red, and two protuberances of the same color occur on the rear end of the body. There are also two conspicuous black plumes extending from the fore end and one from the rear end of the body, on which are also found four pale yellowish tufts of hair. The pupæ are brownish and are inclosed in the cocoon made of silk and hairs. Toward the northern part of its distribution there is only one brood of larvæ each year, but in the central and more southern States, depending upon the latitude, there may be as many as three broods.

There are two other species of tussock moths likely to be found in orchards in certain regions. The antique tussock moth,[31] of European origin, is present in the New England States and adjacent Canada, its general range of distribution, however, extending westward to the Pacific. The California tussock moth[32] occurs only in California apparently, where it has done important injury to apples, cherries, and certain forest or shade trees. Both species can be controlled by the means recommended for the white-marked tussock moth.

The caterpillar of the tussock moth is quite resistant to arsenicals, but can be controlled while young with a spray of arsenate of lead, using the powder at the rate of 2 pounds or the paste at the rate of 4 pounds to 50 gallons of water or fungicide. When the caterpillars are very abundant, much relief can be secured by searching out and creosoting the egg masses as for the gipsy moth (p. 44), or these can be removed and destroyed by burning.

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[30] *Hemerocampa leucostigma* Smith and Abbot.
[31] *Notolophus antiqua* Linnaeus.
[32] *Hemerocampa vetusta* Boisduval.

FIG. 90.—Caterpillars of the white-marked tussock moth feeding upon the foliage and fruit of the apple.

FIG. 92.—Male white-marked tussock moth. Enlarged.

FIG. 91.—Female white-marked tussock moth depositing egg mass on silken cocoon. Enlarged.

FIG. 93.—White-marked tussock moth caterpillars. Enlarged.

HICKORY TIGER MOTH.[33]

This is another insect which sometimes attracts attention in neglected orchards and young orchards not regularly sprayed with arsenicals. The caterpillars are gregarious (fig. 94) and, if not checked in the course of their feeding, may cause considerable defoliation of the trees. This insect, the hickory tiger moth, is well known in the New England States and is often found as far

FIG. 94.—Young caterpillars of hickory tiger moth.

FIG. 95.—The hickory tiger moth.

FIG. 97.—Cocoon of hickory tiger moth.

FIG. 96.—Full-grown larva of the hickory tiger moth.

West as Montana and Missouri, attacking the apple, pear, quince, cherry, hickory, walnut, and many other trees.

The hickory tiger moth hibernates in the pupa stage, usually in trash on the ground. Early in the summer the moths emerge and soon deposit their eggs on the foliage in clusters containing from less than 100 to about 400. The roundish eggs are about one thirty-fifth of an inch in diameter, bluish white when fresh, but later becoming darker. The moths (fig. 95) have rather conspicuous markings, the forewings being mottled with small brownish dots, with three more or less distinct rows of white dots, and having an expanse of approximately 2 inches. Upon hatching, the larvæ feed at first upon the surface of the foliage and later consume the entire leaf except the larger veins. The full-grown larva (fig. 96) is about 1½ inches long and is covered with black and white hairs.

[33] *Halisidota caryae* Harris.

The cocoons (fig. 97) are made among the leaves or trash on the ground and the pupa stage is entered for the winter. There is only one generation of the caterpillars each year, and they are not likely to be troublesome, except during occasional years, and more or less locally.

Orchards thoroughly sprayed with arsenicals will rarely require special treatment for the hickory tiger moth. When found in young orchards it may readily be controlled by the use of arsenate of lead at the usual strength, the spray application being made as soon as the insects are detected. If the caterpillars when discovered are one-third grown or over, an increased amount of poison should be used.

FIG. 98.—Case in which apple leaf-crumpler caterpillar passes the winter. Enlarged.

APPLE LEAF-CRUMPLER.[34]

In the course of the winter pruning, fruit growers often notice a mass of leaves (fig. 98), sometimes in considerable abundance, rather tightly tied to twigs. Upon tearing open such leaf masses, there will be found a considerable number of tough horn-shaped cases, made by the apple leaf-crumpler, in which the larva spends the winter. Although of minor importance, this insect has occasionally become injurious, particularly in nurseries and young orchards. It is a native species, more or less common in the Northern and Central States, and feeds upon the apple, crab apple, quince, cherry, wild cherry, plum, wild plum, peach, pear, and perhaps other host plants.

The winter is passed within the winter case as a half-grown caterpillar (fig. 99), which becomes active in the spring as the buds begin to open. Later bunches of leaves are tied together, among which the caterpillars feed, occasionally attacking the fruit after it is set and sometimes the bark of the new wood. By late spring to early summer the caterpillars are full-grown and attach their cases, in which the pupa stage is passed, to the bark of the tree. A full-grown larva is about three-fifths of an inch long, greenish brown, with a dark brown head. In due time the moths emerge and deposit their very minute eggs over the foliage of the host plant. The forewings of the moth are light brown with silver markings and the wing expanse is about three-fourths of an inch. The larvæ of the new brood feed upon the foliage until late fall, when they attach their cases to the trees as described.

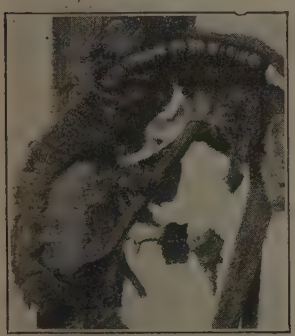

FIG. 99.—Winter case and caterpillar of the apple leaf-crumpler. Enlarged.

Spraying with arsenate of lead at the rate of 1 pound of the powder or 2 pounds of the paste to 50 gallons of water or fungicide is an effective remedy for this insect. The application should be given in the spring shortly after the leaves have begun to push out. In commercial orchards which have received regular sprayings, the leaf-crumpler will rarely, if ever, require special treatment.

[34] *Mineola indigenella* Zeller.

APPLE LEAF SKELETONIZER.[35]

In the Mississippi Valley States the apple leaf skeletonizer is at times the cause of important injury to young orchards (fig. 100) and to nursery trees. The caterpillars feed on the upper side of the leaves, protected by a web of silken threads. They skeletonize the leaves, eating out the soft leaf tissue, the injury giving the foliage a brown, dry appearance. This insect is undoubtedly native and occurs rather generally over the United States east of the Rocky Mountains. Its principal food plant is the apple, but occasionally it attacks the quince and plum.

It passes the winter in the pupa stage in cocoons among the fallen leaves, the moth appearing during the following May and June. This is a small, purplish brown insect, with two silvery gray bands across each forewing. The forewings have an expanse of nearly half an inch. The larva (fig. 101) is pale brownish or greenish, about half an inch long, with four shiny tubercles on the back behind the head. There are two broods of larvæ each year, the first during midsummer and the second in the fall, the last brood changing to pupæ with the coming of cold weather.

This insect will readily yield to thorough spraying of the foliage with arsenate of lead at the usual strengths.

APPLE LEAF-SEWER.[36]

The presence in orchards of the apple leaf-sewer, sometimes called the apple leaf folder, is indicated by the occurrence of leaves folded, as in figure 102, often exhibiting a somewhat scorched appearance and with the upper parenchyma of the leaves more or less consumed. This insect only occasionally attracts attention, usually in unsprayed or neglected orchards or on young apple or nursery trees that do not receive arsenical sprays. It is a native insect and is confined principally to the eastern half of the United States and to certain districts of Canada. The apple appears to be the only plant upon which it subsists, though it is probable that it feeds upon wild crabs and other plants related to the apple.

The insect hibernates as a larva (fig. 103) within the folded leaves that have fallen to the ground. At this time it is about half an inch in length and light gray; the head is yellow with a somewhat darker thoracic shield, bearing a black spot on each side. In the spring the larvæ change to brownish pupæ, from which the moths issue. The adult, or moth (fig. 104), is white, with markings of brown, and the wing expanse is about three-fourths of an inch. The small, flat, oval, yellow eggs are placed on the foliage and are usually securely glued to the under surface of the leaf. Upon hatching, the larva spins a silken web on the lower leaf surface, where it begins eating the parenchyma, gradually folding over as it grows a portion of the lower side of the leaf. After feeding awhile in this somewhat restricted area, it eats its way through the upper tissues and migrates to a near-by leaf, where it begins another web on the lower leaf surface and fastens together the opposite halves of the leaf. The leaves are folded in this way until the larva completes its growth, and thus a single caterpillar will often injure several leaves. The larva remains through the winter within the last leaf attacked, in the fallen leaves on the ground.

In orchards regularly sprayed for the codling moth this species will require no specific treatment. Where for any reason special applications are necessary, arsenate of lead should be used at the usual strength for caterpillars of this character. The raking together and burning in early spring of fallen, infested leaves may also be advisable, if the insect is particularly abundant.

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[35] *Canarsia hammondi* Riley.

[36] *Ancylis nubeculana* Clemens.

FIG. 100.—Apple tree defoliated by apple leaf skeletonizer.

FIG. 102.—Work of the apple leaf-sewer.

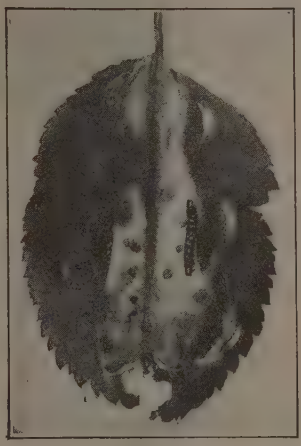

FIG. 103.—Larva of apple leaf-sewer.

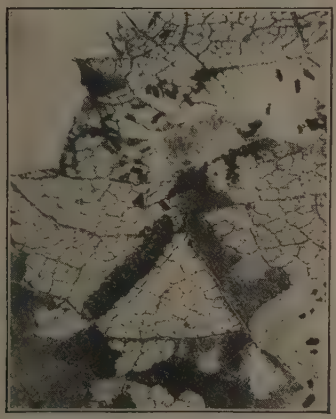

FIG. 101.—Larva of apple leaf skeletonizer and its work on apple leaf. Enlarged.

FIG. 104.—Adult of the apple leaf-sewer.

CIGAR CASE-BEARER.[37]

The cigar case-bearer is another species of minor importance, although it has occasionally been reported as doing considerable damage to foliage (fig. 105) in orchards that have been more or less neglected. It is primarily an apple and pear pest, but also attacks the quince, plum, cherry, and haw. It is thought to be a native species, feeding originally upon wild haws. Although reported principally from the North, it occurs in New Mexico and is likely to be found in most apple sections, since it is readily distributed on nursery stock.

FIG. 105.—Apple leaves injured by cigar case-bearer.

The cigar case-bearer hibernates as a half-grown larva within its case, which is attached to a branch of the tree. The caterpillars become active on the approach of spring and migrate to the opening buds, where they feed upon the expanding foliage and later eat the flower and fruit stems, as well as small holes into the young fruit itself. The black-headed, golden brown larvæ (figs. 106 and 107) quickly develop in size, which necessitates the enlarging of their winter cases, and later in the spring they construct new cigar-shaped cases in which they continue to feed until early summer (fig. 108). Upon completing their growth they migrate to the branches, where they transform successively to light brown pupæ and small, gray moths (fig. 109), with heavily fringed wings, measuring about three-eighths of an inch from tip to tip. The eggs are very minute, yellow, and are usually located along the midrib of the lower surface of the leaves. Upon hatching the larvæ mine within the soft tissue of the leaves, and toward the approach of fall construct their winter cases, migrating in due time to the twigs, where the winter is passed.

Well-cared-for orchards will rarely, if ever, suffer important injury from the cigar case-bearer, and even though it may become abundant it can be easily controlled by spraying with arsenate of lead at the usual strength. A contact spray, as 10 per cent kerosene emulsion, or 40 per cent nicotine sulphate at the rate of one-half pint to 50 gallons of soapy water, may be employed instead of an arsenical.

PISTOL CASE-BEARER.[38]

Another curious little insect closely related to the cigar case-bearer and which occasionally attracts the attention of the orchardist is known as the pistol case-bearer. This insect is usually of minor importance, except in more or less neglected orchards or during seasons of local outbreak, when it may

[37] *Coleophora fletcherella* Fernald. [38] *Coleophora malivorella* Riley.

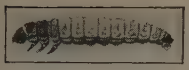

FIG. 106.—Larva of cigar case-bearer. Enlarged.

FIG. 107.—Larva of cigar case-bearer protruding from its case. Enlarged.

FIG. 108.—Larvæ of the cigar case-bearer and their work on apple foliage. Enlarged.

FIG. 109.—Moths of cigar case-bearer emerging from pupal cases.

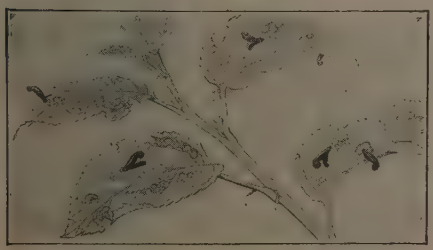

FIG. 110.—Pistol case-bearer and its work on apple foliage.

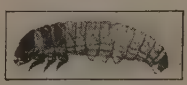

FIG. 111.—Larva of pistol case-bearer. Enlarged.

become prominent. It has about the same distribution as the cigar case-bearer and attacks essentially the same host plants. Although the larvæ usually attack the fruit, the chief damage is done to the flowering parts and foliage. This injury, however, to apple foliage is somewhat different from that caused by the cigar case-bearer, since the larvæ of this species do not mine the foliage, but, instead, eat out irregular patches, thus often skeletonizing the leaves (fig. 110).

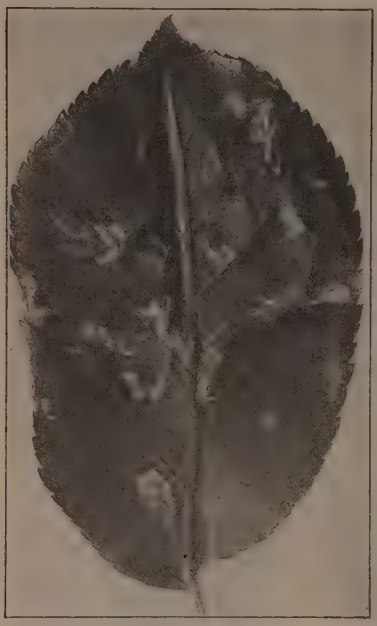

FIG. 112.—Mines of trumpet leaf-miner.

The life history of the pistol case-bearer resembles in a general way that of the cigar case-bearer, the principal points of difference being that the orange-colored larva (fig. 111) does not spend a part of its life as a miner; nor does it construct an entirely new case in place of its hibernaculum. Instead, the larva, as it grows, builds additions to its winter case so as to accommodate its body. The adult is a small, light brown moth, with orange wings which measure about half an inch from tip to tip. The eggs, which are deposited on the foliage, are very minute, reddish brown, strongly ribbed, and suggest a miniature inverted teacup.

The same suggestions given for the control of the cigar case-bearer are appropriate for this species.

TRUMPET LEAF-MINER.[39]

The trumpet leaf-miner is another species of minor importance although the subject of occasional inquiry. Its injuries on different occasions have been of importance, and it has been perhaps more destructive than other related leaf-miners. As the name suggests, the completed mines have somewhat the shape of a trumpet (fig. 112). When abundant, the injury may result in some defoliation of the trees, with consequent injury to fruit buds and fruit. It is thought to be native and doubtless fed originally upon crab-apple trees and wild haws, as it does at the present time. It occurs rather generally throughout the eastern half of the United States and Canada.

FIG. 113.—Larva of trumpet leaf-miner. (Upper epidermis of mine removed.) Enlarged.

The winter is passed in the larva stage within the mines in the fallen leaves (fig. 113), the mines being well lined with silk. The mature larva is about one-fifth of an inch in length, flat, legless, with a pale green body and yellowish brown head. It enters the pupa stage in the spring, and the moths are on the wing by the time the foliage is well out. The tiny moths have a wing expanse of about one-fourth inch, the forewings being brown with a somewhat purplish luster.

[39] *Tischeria malifoliella* Clemens.

The elliptical eggs are exceedingly minute, iridescent, of a greenish yellow tint, and are placed on the foliage. Upon hatching, the larvæ immediately burrow into the upper surface of the leaf, eventually eating out the characteristic trumpet-shaped mines. There are from two to four generations each year, depending upon the locality.

This insect can be destroyed in its mine by the use of contact sprays, such as 12 to 15 per cent kerosene emulsion or 40 per cent nicotine sulphate at the rate of one-half pint to 50 gallons of water, to which should be added 2 pounds of soap which has previously been dissolved with water. Plowing under leaves prior to the blooming period of the apple should aid in its control by burying the overwintering insects, thus preventing the escape of the moths.

SPOTTED TENTIFORM LEAF-MINER.[40]

The spotted tentiform leaf-miner also is of comparatively little importance, but is occasionally the subject of inquiry from observing orchardists. As a larva it makes a small mine on the lower surface of the leaf, but since it does not devour all of the soft tissue, the mine appears spotted when viewed from above. Owing to the crumpling of the leaf, the mine bears some resemblance to a tent, and hence the rather fanciful common name. This insect, of European origin, is now distributed over most of the eastern part of the United States, and has been reported as feeding upon the apple, quince, plum, wild cherry, wild haws, and sweet-scented crab.

It passes the winter in the pupa stage within the mine on fallen leaves. The moths emerge in the spring and deposit their minute eggs on the foliage. The resulting caterpillars are about one-fifth of an inch in length and yellowish. The moths are very small, with brownish forewings on which are white lines and spots, with a black spot at the tip of the wing.

The suggestions given above for the control of the trumpet leaf-miner are applicable to the present species.

UNSPOTTED TENTIFORM LEAF-MINER.[41]

The larva of the unspotted tentiform leaf-miner makes a tent-like mine (fig. 114) on the underside of the leaf somewhat larger than that of the spotted tentiform leaf-miner and, unlike the latter, consumes all of the leaf tissue except the veinlets. It attacks, in addition to the apple, pear, crab apple, haw, plum, and wild cherry. Although sometimes abundant in orchards, it is of very minor importance. It is probably a native species, and is more common in the Northern and Middle States than elsewhere.

The winter is passed in the pupa stage within a cocoon made in the folded edge of a leaf (fig. 115). The pupa is about one-sixth of an inch long and yellowish brown. The small grayish moths issue in the spring and deposit on the foliage, usually on the lower surface, their very minute eggs, which are invisible to the naked eye. The footless larvæ soon hatch and eat their way into the inner leaf tissue, where they start their characteristic mines. The full-grown larva is about one-fourth of an inch long and greenish gray. Several generations are produced yearly, the last brood pupating during the late fall and passing the winter in this condition.

Special remedial measures will seldom be necessary, but if such is the case the most practical means of control is, perhaps, to destroy the overwintering pupæ in the fallen leaves by plowing and disking the orchard in the early spring previous to the issuance of the adults.

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[40] *Lithocolletes blancardella* Fabricius. [41] *Ornix geminatella* Packard.

FIG. 114.—Appearance of apple leaves infested with unspotted tentiform leaf-miner.

FIG. 116.—Serpentine leaf-miner: *A*, Apple twig in fall, showing serpentine mines on leaves and new cocoons at *a* and *a*; *B*, winter twig, showing discolored cocoon at *b*; *C*, cocoon in spring with empty pupal skin projecting, enlarged; *D*, emerged moth resting on side of twig, enlarged; *E*, moth with wings spread, enlarged; *F*, mature caterpillar emerging from slit at end of its mine, enlarged; *G*, *H*, *I*, attitudes of the caterpillar when crawling, enlarged.

FIG. 115.—Pupa of unspotted tentiform leaf-miner. Enlarged.

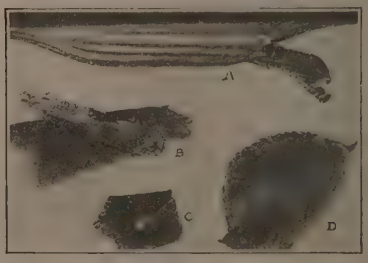

FIG. 117.—Apple bucculatrix: *A*, Cocoon and empty pupal case, enlarged; *B*, moth, enlarged; *C*, egg, enlarged; *D*, work of the apple bucculatrix on foliage.

SERPENTINE LEAF-MINER.[42]

Fruit growers, particularly in the New England States, have frequently had their attention attracted to long serpentine mines on the upper surface of the leaves. These mines (fig. 116, A) are constructed by the so-called serpentine leaf-miner, which is more an object of curiosity than of economic importance.

The insect winters in the larva stage within a small brownish cocoon (fig. 116, C), which is usually attached to a twig or in the crotch of limbs. In the spring the full-grown dark-green larvæ (fig. 116, G, H, I), measuring nearly one-eighth inch in length, transform to greenish pupæ, from which develop the small, dark purplish moths, with crimson, yellow-tufted heads (fig. 116, D, E). The eggs are very minute and are deposited on the foliage, giving rise to larvæ which mine in the leaves in characteristic serpentine fashion.

The insect is controlled by the same measures effective against the trumpet leaf-miner (p. 54).

APPLE BUCCULATRIX.[43]

In the course of the winter pruning the attention of the fruit grower is sometimes attracted to the small, whitish, ribbed cocoons (fig. 117, A) of the apple bucculatrix. These measure about one-fourth of an inch in length and are often built side by side, usually on the lower side of small branches and twigs. Although widely distributed from the Atlantic coast to the Rocky Mountains, it is seldom that this insect causes important injury, except perhaps in instances where the trees have been long neglected. The apple bucculatrix, or ribbed cocoon-maker of the apple, as it is sometimes called, is essentially an apple pest, but has also been recorded as feeding on docks, alfalfa, and certain grasses.

The winter is passed as a pupa within the cocoon. Early in the spring, about the time the foliage begins to expand, the very small, delicate moths (fig. 117, B) commence to issue and deposit their minute, pale greenish eggs (fig. 117, C) on the lower side of the leaves. The moths are light brown, with heavily fringed wings, which have an expanse of about one-tenth of an inch. Upon hatching the young larvæ eat into the leaves and make small mines (fig. 117, D), somewhat less than an inch in length. They then desert the mines and construct on the surface of the leaves small flimsy cocoons in which they molt. After feeding upon the leaf surface for a few days they make a second cocoon for molting purposes, after which they continue their surface feeding for a period of about a week. When the foliage is attacked by large numbers of the caterpillars it will become more or less brown and shriveled. The full-grown larvæ seek a place to build their cocoons, which may be constructed on the foliage, fruit, or twigs. In northern New England there is only one generation, but farther south two generations occur annually, the second brood of moths issuing during the latter part of the summer. The life history and habits of the second brood are similar to those described for the first brood.

Orchards regularly sprayed for the more important apple insects will seldom require special treatment for this pest. The dormant spray treatment with lime-sulphur solution will aid in destroying the overwintering pupæ, and the summer applications of lead arsenate will kill the larvæ that feed on the leaf surface. After pruning the trees the wood should be burned before spring, thus destroying the overwintering pupæ.

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[42] *Nepticula pomivorella* Packard. [43] *Bucculatrix pomifoliella* Clemens

PALMERWORM.[44]

If history repeats itself in the case of the palmerworm, fruit growers are not likely to encounter this insect in injurious numbers more than once in a lifetime, since in the past outbreaks have occurred only at intervals of about 60 years. The injury is caused by the small worms feeding on the foliage in the open or within a few leaves or sometimes beneath the protection of a folded leaf edge. They sometimes skeletonize the foliage when abundant and often eat holes in the young fruit, resulting in a type of injury which may be more or less confused with that caused by the green fruitworms (p. 21). In addition to attacking the fruit and foliage of the apple, the palmerworm has been reported as feeding principally upon the foliage of pear, plum, cherry, and oak. It has been reported chiefly from New York, the New England States, and Canada.

FIG. 118.—Apple leaf infested with pear leaf blister mite.

The palmerworm supposedly hibernates in the adult or moth stage. The moths are of a variable gray to brown color and measure about half an inch across the expanded wings. Early in the spring, upon the appearance of the foliage, the moths deposit their very small whitish eggs on the underside of the leaves, and from these hatch the destructive worms or larvæ. When full-grown the larvæ are about half an inch in length and are usually of a dark green color traversed by four whitish stripes, the outer of which are broader than the inner. After feeding for a period of about a month, the larvæ transform to small brownish pupæ, which are secured to the leaves by means of silken threads or in some instances are to be found on the ground. Through further transformation the moths issue during midsummer, but do not oviposit, so far as is known, until the following spring. There is thus only one generation annually.

In common with many other leaf-feeding caterpillars, the palmerworm may be controlled by means of a spray consisting of arsenate of lead powder 1 pound, or paste 2 pounds, to 50 gallons of water or fungicide, applied at the time of hatching. If the worms are not discovered until partly grown, it may be necessary to use a stronger dosage, depending on their size.

PEAR-LEAF BLISTER-MITE.[45]

The pear-leaf blister-mite attacks the foliage of the apple and pear, producing minute greenish or reddish galls or blisters, which after a time turn brown, spotting the leaves with dead areas like certain forms of fungous attack (fig. 118). When the galls are abundant, there results considerable dead and injured tissue, giving the leaves a brownish and shriveled appearance. Badly infested orchards have a distinctly yellowish cast, and later become brownish as the injured patches discolor. Injury to the foliage causes much of it to

[44] *Ypsolophus ligulellus* Hübner. [45] *Eriophyes pyri* Pagenstecher.

fall, with consequent damage to the tree and fruit crop. The fruit itself is sometimes injured, as shown in figure 119. The pear is more generally infested by this species than the apple, and the service-berry and other host plants are also attacked. While not a pest of first-class importance to apple growers generally, nevertheless its injuries in some localities must be provided against. Damage to the apple has been especially pronounced in New England, in portions of New York, and more recently in certain apple-growing districts in Washington. Recently apple leaves infested by this mite have come from Mississippi. The pear-leaf blister-mite is of European origin and was probably introduced into this country many years ago on nursery stock. It is now widely distributed in the United States wherever pears are grown.

The winter is passed in the adult stage beneath the bud scales. The adults (fig. 120) are very small, elongate, whitish, and measure about one one hundred and twenty-fifth of an inch in length. In the spring, when the leaves are unfolding, the mites enter through the lower epidermis, and their activities soon bring about the blisterlike galls in which they live and multiply. After reaching maturity, the mites desert the old galls, make new ones, and produce a new generation. A succession of generations is thus developed each season up to the approach of cold weather, when the mites migrate to the bud scales, beneath which they hibernate.

FIG. 119.—Injury to fruit by pear-leaf blister mite.

If it is necessary to spray the orchard for the San Jose scale, no special treatment for the pear-leaf blister-mite will be required. It is readily controlled by the use of commercial lime-sulphur (32° Baumé) 6½ gallons with water sufficient to make a total of 50 gallons, as employed in the control of the San Jose scale. If the application is for the mite only, a somewhat weaker spray will answer, using 5½ gallons of the concentrate and sufficient water to make 50 gallons. The application may be made after the leaves have dropped in the fall, or in the spring before the buds have swollen to any extent. Miscible oils and kerosene emulsion of standard dormant tree strengths may also be used effectively.

RED SPIDER.[46]

The injury to the apple by the red spider results from the sucking out of plant juices, giving the foliage an unhealthy, mottled appearance. If the attack is severe, the injury may be quite important, resulting in defoliation of the trees and interference with the proper development of the fruit and fruit buds. This mite is likely to be most troublesome during dry seasons, and in arid or semiarid regions it is a pest of importance. Its injuries, however, are often confused with those of the clover mite (p. 60). The red spider is widely disseminated throughout the United States and attacks the apple and many other deciduous fruits, cultivated flowers, vines, truck crops, etc. It is preeminently a pest in greenhouses and requires constant vigilance on the part of growers to keep it in check.

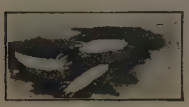

FIG. 120.—Adults of pear-leaf blister mite. Greatly enlarged.

[46] *Tetranychus telarius* Linnaeus.

The winter is passed in the adult stage beneath fallen leaves, weeds, and trash. The adult female (fig. 121) is about one-sixtieth of an inch long, varies in color from a russet green to almost black, but is usually dark red, and is generally marked with two large, dark spots on each side of the body. The male is smaller and is russet salmon, with the lateral spots less conspicuous than in the other sex. The eggs are globular and when freshly laid are clear, gradually turning opaque and later a dark straw color. The newly hatched mite is round, colorless, with six legs, and is about the same size as the minute egg, which is about one two hundred and fiftieth of an inch in diameter. The mites spin a very fine web over the leaf and feed under this protection. There are several generations during the season.

FIG. 121.—Female red spider. Greatly enlarged.

Dusting the trees with a mixture of 50 per cent sulphur and 50 per cent hydrated lime is recommended for controlling the red spider, as is also spraying with summer-strength lime-sulphur wash.

CLOVER MITE.[47]

The clover mite, known also as the brown mite, is very small, scarcely as large as a pinhead, reddish or brownish, and readily recognized under a hand lens by its unusually long front legs (fig. 122). In the Middle West and the Eastern States this mite is of importance principally on account of its damage to clover and various grasses, its injuries to fruit trees not, as a rule, attracting attention except during periods of drought. It is, however, sometimes complained of by householders, since during the fall the mites may enter dwellings, often in large numbers, and become a decided nuisance. In the more arid sections of the country, particularly west of the Rocky Mountains, the clover mite becomes one of the important orchard pests attacking most stone and pome fruits. Badly infested foliage assumes a yellowish, sickly appearance due to the injuries of the mites, and by midsummer or early fall much of it may drop to the ground. In the East such injury is not uncommon to trees in sheltered locations and, in fact, in orchards where conditions are favorable for the development of the mites. In warmer climates the clover mite

FIG. 122.—Adult clover mite. Greatly enlarged.

[47] *Bryobia pratensis* Garman.

may hibernate on the trees either in the adult or egg stage. In northern localities, where the temperature is more severe, eggs are deposited by the mites in the fall on twigs around bud scales, crotches of limbs, etc., and thus the winter is passed. The eggs are small, globular, and reddish, often occurring in large numbers and attracting the attention of orchardists during pruning operations. With the pushing out of the foliage in the spring, the eggs hatch and the mites attack the leaves, producing several generations during the season.

FIG. 123.—The differential grasshopper.

The eggs and hibernating adults of the clover mite on trees, as a rule, will be destroyed by a thorough spraying with lime-sulphur solution, using the concentrate 32° Baumé during the dormant period at the rate of 6½ gallons diluted with water to make 50 gallons, a strength which is also effective against the San Jose scale. For the control of the insect on trees in foliage, use freely a dust of finely divided sulphur and hydrated lime, half and half. If desired, the sulphur may be mixed with soapy water and sprayed on the plants, using sulphur at the rate of 10 pounds to 50 gallons of water. Kerosene emulsion, 10 per cent strength, or fish-oil soap, 1 pound in 10 gallons of water, are also effective as summer sprays.

FIG. 124.—Apple tree defoliated by grasshoppers.

GRASSHOPPERS.[48]

Several species of grasshoppers, one of which is shown in figure 123, at times occasion injury to apple trees by feeding upon leaves (fig. 124) or chewing the bark. During periods of serious outbreak this injury may be very important, and prompt and energetic measures are necessary to prevent destruction of the trees. Grasshopper injury is rarely of importance in the Eastern States, except in orchards adjacent to meadows which have recently been cut. In the West, however, injury in connection with grasshopper outbreaks may be much more important.

Most grasshoppers of importance to apple growers winter in the egg stage, the eggs being placed in podlike masses below the surface of the soil. The nymphs, or young insects, hatch in the spring and begin feeding on various kinds of plant growth. They mature during the summer and lay their eggs in the fall along roadways, headlands, meadows, etc.

In controlling grasshoppers the soil where the eggs are laid should be plowed or disked at any convenient time prior to the hatching period. A favorite means of combating grasshoppers at this time is to distribute here and there

[48] Red-legged locust, *Melanoplus femur-rubrum* DeGeer. Lesser migratory locust, *Melanoplus atlanis* Riley. Rocky Mountain or migratory locust, *Melanoplus spretus* Thomas. Differential locust, *Melanoplus differentialis* Thomas. Carolina locust, *Dissosteira carolina* Linnaeus. Two-striped locust, *Melanoplus bivittatus* Scudder.

in the orchard bran-mash poisoned bait made according to the following formula:

Part 1.		
Paris green (or white arsenic)	pounds	2½
Bran	do	50
Part 2.		
Lemons (pulp and rind finely chopped)	fruits	6
Molasses (low grade preferred)	gallon	1
Water	gallons	5

Mix thoroughly the ingredients of part 1; next mix together the materials of part 2, first adding to the water the lemon juice and the pulp and rind finely chopped, and finally the molasses. When ready to use, mix thoroughly the ingredients of parts 1 and 2 and add sufficient water to make a wet mash. The mash should be thoroughly scattered broadcast early in the morning, preferably when the soil is damp, at the rate of from 3 to 5 pounds to the acre. In arid regions the mash should be scattered along damp irrigation laterals, since it quickly hardens and when dry is not readily eaten by the insects.

FIG. 125.—Hopperdozer for catching grasshoppers.

A further protection may be afforded fruit trees by spraying with arsenate of lead at the rate of 2 pounds of the powder or 4 pounds of the paste to each 50 gallons of water or fungicide.

A type of apparatus known as the hopperdozer, having shallow compartments to hold kerosene, as shown in figure 125, is frequently used. This is drawn through the orchard by a team, and the grasshoppers are killed when they leap into the pans containing the oil.

SAN JOSE SCALE.[49]

The San Jose scale, while a comparatively small and insignificant appearing insect, is, owing to its great powers of reproduction, a pest of first-class importance. Two or three decades ago it was the center of attention by orchardists and others, and was the cause of losses amounting to many millions of dollars. It is thought to have been introduced from China, and was first found in this country in San Jose, Calif., about 1870. Since its introduction it has been distributed by means of nursery stock and other agencies to practically all of the principal fruit districts of the United States. The development of effective and economical sprays, especially lime-sulphur wash, has enabled fruit growers satisfactorily to control the pest, and they now have full confidence in their ability to keep it reduced below injurious numbers.

At the present time the insect throughout much of the fruit-growing regions of the Central and Northern States is of much less importance as an orchard pest than formerly, due apparently to several factors. Probably one of the most important of these is the general use by orchardists of dilute lime-sulphur

[49] *Aspidiotus perniciosus* Comstock.

as a summer spray, which, observations and experiments have shown, is effective in destroying many of the newly hatched insects, so that the trees are kept fairly well freed of the pest as an incident to the use of the wash for other purposes. The effectiveness of parasitic and predatory insect enemies in reducing the scale has also apparently been gradually increasing. In fact, the scale in certain orchards has become so reduced in numbers that it has been found feasible occasionally to omit the dormant treatment without undue increase of the insect. Such omission, however, if made, should be based on very careful examination of the orchard to ascertain whether such practice is warranted. Under favorable seasonal conditions the scale is able to increase rapidly and may do serious damage to the twigs and in spotting the fruit, although present on the trees during the dormant period in apparently negligible numbers.

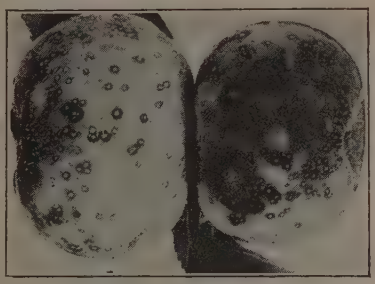

FIG. 126.—Apples spotted by San Jose scale.

In common with other scale pests, the San Jose scale is a sucking insect, and lives upon plant juices which it extracts from the twigs, limbs, trunk, foliage, and fruit. Small reddish discolorations will frequently be found at the point of feeding, and on the fruit itself these dots are conspicuous, unsightly, and lower its market value (fig. 126). When abundant this insect is capable of killing young trees within a few years, and older trees may ultimately be destroyed, although the process is a slower one (fig. 127). Infested trees are dwarfed and unthrifty in appearance, and the incrusted twigs have an ash gray color (fig. 128). Some years ago it was not uncommon to find entire orchards destroyed, but in recent years the trees have been well protected from its ravages by means of spray solutions. It should not be inferred, however, that the San Jose scale is no longer a dangerous pest, since in the absence of adequate treatment it could readily reestablish itself in numbers that would again result in enormous losses to the fruit industry. It has been estimated that from the progeny of a single female there may result over 1½ billion females in the course of one season. From this the fruit grower will appreciate how readily this insect can reinfest and destroy an orchard. The apple, pear, and peach are its favorite food plants. Other deciduous fruit trees are subject to attack, as are also many bush fruits, shade and forest trees, and shrubs.

FIG. 127.—Apple tree practically killed by San Jose scale.

At the approach of winter the San Jose scale is found in practically all stages, from the very young to the mature, but nearly all of the individuals die except those that are about half developed—the stage in which the scale seems best to resist winter conditions. In the spring the scales that have successfully survived the winter continue their development until they reach maturity, after which the females produce their living young. There are several generations during the course of the growing season, depending upon the locality. The waxy scale which protects the yellowish, sac-like body of the female is circular, about the size of a pinhead, grayish, with a central nipple (fig. 129), while that of the male is oval, dark gray, with the nipple, or exuvium, toward the small end of the scale (fig. 129). The adult male is orange colored and has two delicate wings. The young scales, or nymphs, are smaller and have a blackish scale-covering with a central nipple.

FIG. 128.—Twig incrusted with the San Jose scale.

The best and safest spray is concentrated lime-sulphur solution, testing 32° Baumé, diluted at the rate of 1 gallon to 7 of water or approximately 6½ gallons to each spray tank of 50 gallons capacity. This wash may be applied any time after the leaves have dropped in the fall, provided the temperature is not freezing, and before the buds open in the spring. The dormant spraying, however, is usually deferred until after the winter pruning has removed much of the infested wood, thereby securing better results and saving spray material. If it is desired to spray for apple aphids, the dormant application may be delayed until the bud tips show green, when the same lime-sulphur solution combined with three-eighths of a pint of 40 per cent nicotine sulphate to each 50 gallons may be employed to combat both scale and aphids. Owing, however, to the limited time available for this work before the foliage has advanced too far, adequate equipment is necessary to accomplish the work in an effective manner. Miscible oils may also be used in cases of severe infestation, and are effective in the control of the scale, but injury to the trees sometimes results from their use. During the summer season the young scale insects are killed by the summer strength of lime-sulphur concentrate (1½ gallons to 50 gallons of water), and spotting of the fruit is thereby considerably reduced.

FIG. 129.—San Jose scale: Males and females. Greatly enlarged.

OYSTER-SHELL SCALE.[50]

The oyster-shell scale is of common occurrence, and because of its characteristic appearance (fig. 130) is readily identified by orchardists and others who may discover its presence on their trees. It is apparently not very fastidious, being found on a great variety of fruit and shade trees, bushes, and shrubs. Poplar was long supposed to have been a favorite food plant, but it is now believed that the insect most commonly found on poplar is not the same as the apple form. Frequently the oyster-shell scale is found in apple orchards, and although it usually ranks as a scale pest next to the San Jose, it is seldom very destructive. It sucks out the plant juices from the trees, limbs, trunks, foliage, and fruit, the principal injury occurring on the woody portions of the tree. Young trees heavily incrusted are sometimes killed, while older trees may occasionally be seriously injured, resulting in the death of twigs and limbs. On the fruit the scale causes small reddish dots, somewhat similar to those produced by the San Jose scale, thereby disfiguring the fruit and rendering it objectionable from the marketing standpoint.

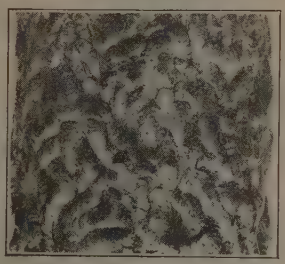

FIG. 130.—Twig incrusted with oyster-shell scale. Enlarged.

The winter is passed in the egg stage beneath the scale covering. The eggs (fig. 131), which are yellowish white, hatch in from 2 to 3 weeks after the apple blooms and shortly thereafter the young yellowish white scale insects settle on some part of the host plant. The male insects are winged, and upon reaching maturity during the summer mate with the females. The female scale covering is about one-eighth of an inch long, dark brownish gray, and resembles in general shape the oyster shell. The male scale covering is much smaller and is oval. In the North, where there is only one generation annually, egg laying takes place during late summer to early fall. In the more southern districts, including the southern parts of New Jersey and Pennsylvania, there are two generations yearly.

FIG. 131. — Appearance of eggs of oyster-shell scale. Enlarged.

While dormant treatment with winter-strength lime-sulphur solution is not generally as effective against the oyster-shell scale as against the San Jose scale, orchards regularly sprayed for the latter will not usually be troubled with the oyster-shell scale. In cases of severe infestation the dormant spraying may be supplemented with a contact spray of 10 per cent kerosene emulsion applied when the young are hatching.

SCURFY SCALE.[51]

Apple and pear trees, as well as other common deciduous tree and bush fruits, are frequently attacked by the scurfy scale, which retards the growth and vitality of its host. In severe infestations this scale has been known to kill young trees, but usually injury is confined to a few twigs or limbs. Occasionally it settles and feeds upon the fruit, resulting in reddish dots somewhat larger than those caused by the San Jose scale. The scurfy scale (fig. 132) is native to the United States, and

[50] *Lepidosaphes ulmi* Linnaeus. [51] *Chionaspis furfura* Fitch.

while it is widely disseminated, it attracts most attention in the New England and Middle Atlantic States. It is readily recognized by the characteristic dirty white, pear-shaped scale, somewhat less than one-eighth of an inch in length, which covers the yellowish female insect (fig. 133). The male scale-covering is snowy white, elongate, and only one twenty-fifth of an inch long (fig. 133). The eggs and the young are purplish, tinted with red.

FIG. 132.—The scurfy scale. Enlarged.

As in the case of the oyster-shell scale, this insect winters as eggs, which begin hatching shortly after the young apples have set. In the Northern States there is only one brood, while in the extreme South there are probably as many as three.

The remedial measures suggested for the control of the San Jose and oyster-shell scales are appropriate for the present species.

PINHOLE BORERS.

The three species of beetles here treated are known to attack the limbs and branches of the apple, boring small pinholes directly through the bark and into the wood. The pinhole borers which penetrate into the wood of the trees are also known as ambrosia beetles, because they feed upon ambrosia fungi which grow along the walls of their burrows. In addition to stone and pome fruits, many kinds of trees are subject to injury, usually after they have been weakened by other causes. One of the forms, the so-called pear-blight beetle,[52] bores into the branches of apple, pear, etc., and may cause a dying-back of the wood, the injury resembling that due to a disease known as pear blight. Another species, the apple wood-stainer,[53] as the name suggests, is associated with a staining of the wood along the burrows of the beetle, due to the growth of one of the ambrosia fungi. A frequent companion of this beetle is another form similar in appearance and habits.[54]

FIG. 133.—Female and male scurfy scales. Greatly enlarged.

When remedial measures for the Ambrosia beetles are necessary, the recommendations given for preventing injury by the fruit-tree barkbeetle should be employed.

FRUIT-TREE BARKBEETLE.[55]

The fruit-tree barkbeetle, also called the shot-hole borer, though closely related to the pinhole borers, differs materially in the character of its attack. Its injuries are confined principally to sickly or diseased trees, or to diseased limbs, and are not as a rule the primary cause of death of trees, though usually so regarded by fruit growers.

[52] *Anisandrus pyri* Peck.
[53] *Monarthrum mali* Fitch.
[54] *Monarthrum fasciatum* Say.
[55] *Scolytus rugulosus* Ratzeburg.

Both the beetles and grubs or larvæ burrow into the bark and slightly into the wood, rapidly extending their burrows and destroying the vital part of the tree. On a tree that has been infested for some weeks the entrance and exit holes of the beetles may be so abundant as to suggest that the tree has been peppered with shot (fig. 134). This insect is of European origin and is now widely distributed over the United States east of the Mississippi, and in numerous localities farther west. It attacks most pome and stone fruits, as well as mountain ash, chokecherry, June berry, wild plum, service berry, and perhaps other plants.

During the winter season the fruit-tree barkbeetle is in the larva or grub stage within the larval galleries. The mature larvæ are whitish and are about three-sixteenths of an inch long. They pupate early in the spring and the beetles, which are about one-tenth of an inch in length and dark brown, emerge in late spring to early summer, according to the latitude. The females proceed to the trees and burrow through the bark until the sapwood is reached, where they make a round hole about the size of a pinhead. They then gnaw out a somewhat larger tunnel for a distance of about 2 inches parallel with the grain of the wood. Along the sides of this brood chamber small cavities are made, into each of which an egg is placed. These eggs hatch in a few days and the larvæ as they grow tunnel between the bark and sapwood in a direction at right angles to the brood chambers to a distance of about 3 to 4 inches. Upon attaining their full growth the larvæ pupate in cells just under the outer part of the sapwood. Shortly, through further transformation, the adults appear and cut their way out through the bark, making exit holes similar to those made by the females in entering the tree. In the North there are two generations a year, while in the South at least three and possibly four generations develop annually.

FIG. 134.—Exit holes of fruit-tree barkbeetle.

To prevent injury by this insect great care should be taken to remove all breeding places within or adjacent to the orchard. Sickly trees will harbor the fruit-tree barkbeetle and in this way large numbers of the pest will become established within the orchard. Cutting out and destroying infested trees and limbs and maintaining the trees in a thrifty condition will vastly reduce the injury of this pest. Where prunings are piled up and allowed to remain near orchards, the beetles often develop in numbers, attack more or less weakened trees, or even healthy trees, and by their repeated onslaughts do considerable harm, or eventually cause the trees to succumb. Thorough destruction of such prunings and weakened trees will usually correct such a situation, and the more or less healthy trees should be stimulated with a nitrogenous fertilizer, such as nitrate of soda, and cultivation. After a tree has once become infested there is no practical method of destroying the insects under the bark. A heavy application of whitewash in the spring just before the beetles begin their attack will act as a moderate preventive.

BUFFALO TREE-HOPPER.[56]

The injury caused by the buffalo tree-hopper is due to the punctures made by the females in egg laying and the scars resulting therefrom. The female, with her ovipositor, cuts two slits in the bark on the upper side of the smaller branches. The bark between the cuts is loosened and the twigs roughened and weakened (figs. 135 and 136). In most sections the buffalo tree-hopper is not an enemy of importance to the apple, though there are records of serious injury in the upper Mississippi Valley. Young trees usually suffer worst, and where the egg punctures are abundant growth of the twigs is retarded. It is a native species and is rather generally distributed over the Middle and Eastern States, ranging into Canada, but has always attracted most attention in the Middle West. The buffalo tree-hopper feeds upon a considerable number of pome and stone fruits, upon the locust, cottonwood, thornbush, etc., as well as numerous vegetables.

The insect winters in the egg stage in the little cuts made by the female. The eggs are one-tenth of an inch long, cylindrical, whitish, and some dozen or less are placed side by side in the incisions in the twigs. The eggs hatch in the spring and the young nymphs feed upon various weeds in the vicinity until they reach the adult stage. At this time the insect (fig. 137) is about three-eighths of an inch in length, grayish, triangular, with enlarged prothorax, suggesting in miniature the appearance of a buffalo.

The most practical method of control consists in keeping down the weeds and other food plants of the insect by clean cultivation in and around the orchard. In the work of pruning scarred twigs should be removed and burned to insure the destruction of the overwintering eggs.

PERIODICAL CICADA.[57]

Few insects have attracted as much public attention as the periodical cicada, more popularly known as the "17-year locust." In northern localities this insect appears every 17 years, or oftener where the broods overlap, whereas in the South the life cycle is completed in 13 years. The forthcoming of the locusts is usually heralded by announcements in the newspapers and by other agencies. Frequently the accounts of the impending danger to orchards and shade trees are much exaggerated and cause an unwarranted fear of destruction. The chief injury to trees is caused by the females ovipositing in the twigs; young orchards adjacent to woods often suffer severely, and in extreme cases young trees may be killed. Older trees suffer much less, particularly if the winter pruning is omitted previous to the "locust year." The punctured twigs (figs. 138 and 139) are more or less weakened and break off readily and are also more subject to attack along the egg scar by the woolly apple aphis.

The periodical cicada is a native pest and is found widely distributed over the Atlantic Coast States and the Middle Western States. The females oviposit in the apple, pear, and other deciduous fruit trees and many forest trees, as oak, hickory, etc., but avoid pines, cedars, and other trees that exude gummy substances.

In the spring of the "locust years" the nymphs leave the soil and migrate to the trunks, limbs, and foliage of adjacent trees, where they molt, the cast skins (fig. 140) remaining rather firmly attached to the point chosen. Within a week or so the females are actively depositing their eggs, which do not

[56] *Ceresa bubalus* Fabricius. [57] *Tibicina septendecim* Linnaeus.

FIG. 135.—Injury to twigs by buffalo tree-hopper.

FIG. 136.—Work of the buffalo tree-hopper.

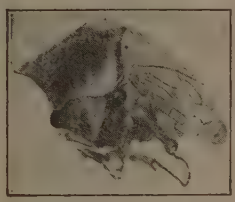

FIG. 137.—Adult buffalo tree-hopper. Enlarged.

FIG. 138.—Injury to twigs caused by periodical cicada in depositing eggs.

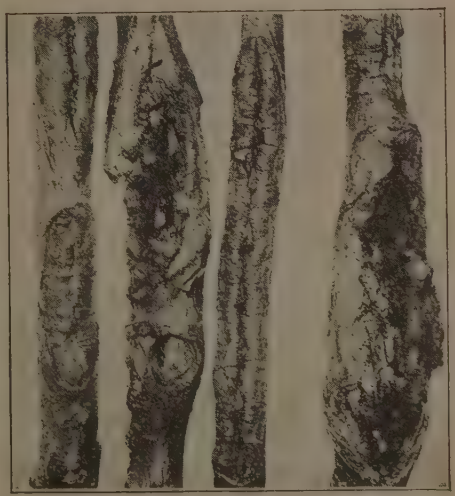

FIG. 139.—Appearance of punctured twigs a few years after cicada attack.

hatch until a month and a half or two months after being laid. The adult (figs. 141 and 142) measures about 1¼ inches and is black, the eyes, legs, and the margin of the upper veins being orange red. Near the tip of each of the forewings is a marking that resembles the letter **W**. The eggs are about one-twelfth of an inch in length, pearly white, and slightly curved. The newly hatched larva is yellowish white with reddish eyes. It burrows into the ground, where as it grows it continues to feed upon the roots of plants until the next "locust year" arrives. Probably no important injury follows this subterranean feeding, even in the worst infested localities.

FIG. 140.—Cast nymphal skin of periodical cicada. Enlarged.

As a matter of precaution it is best not to set out young orchards during the spring of a "locust year," and in orchards already established, especially of young trees, the winter pruning preceding the scheduled arrival of the cicada should be lighter than usual or omitted until the insects disappear. After the visitation has passed the injured wood should be pruned out and destroyed by burning before the eggs hatch. Little, if any, success has followed the use of insecticides against the adults. Prized plants around the home can best be protected from attack by use of mosquito netting or wrappings that will prevent the oviposition of the adults.

SNOWY TREE-CRICKET.[58]

Apple orchards more or less neglected and grown up with weeds and other rank vegetation or surrounded with such growths are sometimes injured by females of the snowy tree-cricket (fig. 143) in the course of its egg laying. The eggs (fig. 143) are deposited singly in punctures in the smaller branches of the apple and other trees. These punctures in themselves are of but little importance, but they often form a starting place for fungous diseases and thus become enlarged into cankerous brown spots of some size which do material injury as they develop. Colonies of the woolly aphis are often found at these places. The feeding and egg-laying habits of tree crickets favor the dissemination of bark diseases of the apple, as careful studies have shown.

FIG. 141.—Two periodical cicadas resting on twig.

The snowy tree-cricket passes the winter in the egg stage in the punctures made in apple twigs and other plants, the young developing in late spring. The crickets feed on a variety of substances, including such other insects as plant lice, plant material, and often ripe fruit, in which they eat out holes sometimes attributed to bees.

Well-cared-for orchards will not suffer from injury by this insect. Where tree-cricket cankers are found, they should be cut out and the surface treated with a good wound paint.

[58] *Oecanthus niveus* DeGeer.

ROUNDHEADED APPLE-TREE BORER.[59]

The roundheaded apple-tree borer, which is now widely distributed throughout the eastern half of the United States, is the most important of the apple-tree borers and is responsible for the killing of many young trees. The injury is caused by the larvæ or borers (fig. 144) feeding upon the inner bark and wood, several of which may often be found in the same tree. Infested trees may be detected by the reddish castings which are forced out through small holes near the base of the tree (fig. 145), and often there will be small oval holes in the trunk some 8 or 10 inches from the ground from which the adult has already escaped (fig. 146). The more important food plants include the apple, quince, pear, serviceberry, wild crab, and mountain ash.

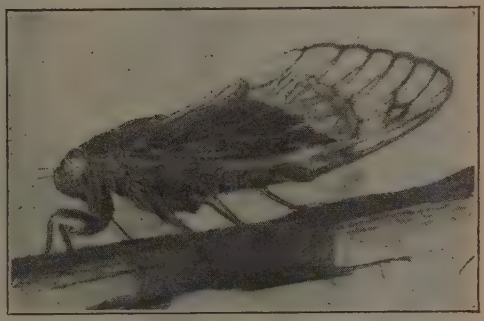

FIG. 142.—Adult periodical cicada. Enlarged.

The winter is passed in the larva stage within the burrow near the base of the tree, though the larvæ that are to transform in the spring to the adult stage are to be found in the pupal chamber. The larva, when mature, measures about an inch in length, is legless, and has a broad thorax with a relatively small dark head. The pupa (fig. 147) is yellowish white, with small spines on its back. Pupation occurs about the blooming time of the apple; and later, through further transformation, the adult (fig. 146) appears. The beetle measures about three-fourths of an inch in length, has long antennæ, and the wing covers are light brown with two longitudinal white stripes, which also are found on the thorax and head. When ready to issue during late spring and early summer, the beetle cuts its way through the bark, leaving an exit hole as described. After emergence it spends considerable time among the branches of the trees, where it feeds to a certain extent upon the bark and also on the midribs and stems of the leaves. The females (fig. 148) usually begin to oviposit within a week or 10 days after emergence. The rusty brown eggs, about one-eighth of an inch in length (fig. 149), are laid in small cuts made by the beetle with its jaws on the trunk near the base of the tree. Usually two or three eggs are deposited by a beetle at one time on the same tree. Upon hatching the larvæ burrow into the inner bark and feed thereon until late in the season, when they usually cut their way into the sapwood, where the winter is passed. In the spring the feeding is resumed, the larvæ penetrating the solid wood. Some individuals have a life cycle of 2 years, while others have one of 3 years.

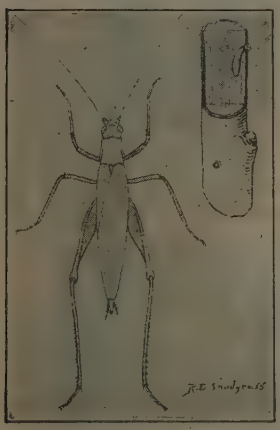

FIG. 143.—Snowy tree cricket, female, and section of twig showing egg and egg puncture. Enlarged.

[59] *Saperda candida* Fabricius.

FIG. 144.—Roundheaded apple-tree borer, second summer in tree.

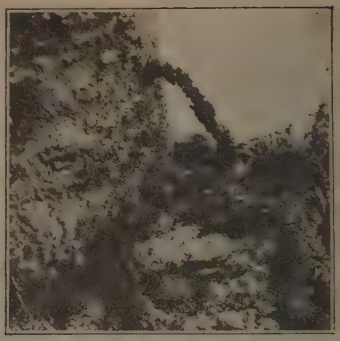

FIG. 145.—Castings of roundheaded apple-tree borer at base of apple tree.

FIG. 146.—Adult roundheaded apple-tree borer just emerged from exit hole in bark.

FIG. 147.—Pupa of roundheaded apple-tree borer. Enlarged.

FIG. 149.—Eggs of roundheaded apple-tree borer. Greatly enlarged.

FIG. 148.—Adult female of the roundheaded apple-tree borer in the act of depositing an egg.

The borer with a 2-year life cycle eats out a burrow during the summer, forming at its end the pupal chamber in which it pupates the following spring, whereas the insect with a 3-year cycle feeds within the solid wood for another season and then prepares its pupal cell from which the adult issues the following year.

Worming trees by means of a knife and wire to hook out the larva from its burrow is the method of control most frequently practiced. The position of the gallery is best located by means of the stringlike mass of reddish castings pushed out at the base of the tree. When the larva is in the pupal chamber it can not be readily reached by the wire because the gallery is plugged with woody tissue; in this event a small piece of cotton saturated with carbon disulphid may be inserted in the burrow, after which the hole should be plugged with moist earth so as to confine the fumes. If worming is done regularly each fall as soon as possible after the eggs have hatched, and special attention given to finding and destroying the young borers still working in the sapwood, the task of worming will be lightened and the more serious injury to the tree from older borers avoided.

In the latitude of Washington, D. C., worming as a rule should be completed before September, while farther south it may be done a month or so earlier, and in the North it may be deferred until the middle of September.

Host plants other than cultivated fruit trees should not be allowed to grow near the orchards, since they serve as breeding grounds for the beetle.

Paints and washes are sometimes used to deter the beetle from ovipositing. Various results have been obtained from their use. If paint is employed, it should be of pure white lead and raw linseed oil mixed to a consistency somewhat thicker than that used in general painting. The earth should first be removed from the base of the tree to a depth of 3 or 4 inches and the bark scales and dirt scraped from the trunk for a distance of about a foot above the ground. The paint should then be applied to the prepared part of the trunk with a brush, and after it has dried the earth should be replaced.

Tree-protectors made of newspapers, building paper, wood veneer, and cylinders of fine-meshed wire screen, the tops of which have been plugged with cotton, are sometimes used to prevent the beetle from ovipositing around the base of the trees.

The arsenical sprays regularly used in commercial orchards against other insects are of some value in killing the adults, which feed to a certain extent upon the leaves and twigs as described.

FLAT-HEADED APPLE-TREE BORER.[60]

The flat-headed apple-tree borer is second in importance to the roundheaded borer and, unlike the latter, seldom attacks vigorous, healthy trees. It will, however, infest those that are weakened from various causes, particularly trees that lean strongly one way (fig. 150), thus exposing a portion of the trunk to the sun, where the beetles freely oviposit. The larva or borer (fig. 151) causes injury to apple trees (fig. 152) by feeding between the bark and sapwood of the trunk and larger branches. On young trees a single borer may nearly or actually kill them, especially newly planted trees that fail to start off right. A related species[61] is frequently complained of on the Pacific coast on account of its injuries to young trees. The larvæ usually are present on the sunny side of the trees, especially in the case of large ones, and the dead area may be enlarged from year to year by successive generations eating out the fresh tis-

[60] *Chrysobothris femorata* Fabricius. [61] *Chrysobothris mali* Horn.

FIG. 150.—A leaning tree having trunk exposed to direct rays of sun is very likely to be attacked by the flatheaded apple-tree borer.

FIG. 151.—Flatheaded apple-tree borer feeding between bark and wood of apple tree.

FIG. 154.—Eggs of flatheaded apple-tree borer. Enlarged.

FIG. 152.—Apple tree girdled and killed by flatheaded apple-tree borers.

FIG. 153.—The flatheaded apple-tree borer (adult). Enlarged.

sues adjacent to the old. While this insect seldom produces visible castings, its presence nevertheless can be frequently detected by the darker and slightly depressed bark over the area in which the borers are feeding. The flat-headed borer is native to this country and is generally distributed in important fruit-growing regions. It feeds upon a wide variety of hosts, including the apple and other deciduous fruit trees as well as many forest trees.

The winter is passed in the larva stage within a pupal chamber formed at the end of a gallery which extends into the wood to a depth of an inch or more. In the South, however, the pupal chamber is generally constructed between the wood and the bark. The full-grown larva measures about an inch in length; is legless; has a broad, flat head, which has suggested its common name, and is pale yellow. The larva transforms to a yellowish pupa in the spring, and issues as an adult shortly after the apple blooms. The adult (fig. 153) is a rather flat beetle, having a dark metallic color, and measures about a half inch in length. The beetles are active and frequent the sunny side of the trees. After mating, the females search the bark for a crack or opening in which to deposit their eggs. The eggs (fig. 154) are about one-fiftieth of an inch long, ribbed, and yellowish. They hatch in the course of 2 or 3 weeks and the larvæ begin to gnaw their way beneath the bark, where they feed and develop, provided the trees are not in good health. The borer is unable to thrive in vigorous trees having a strong flow of sap, although it will sometimes continue to live in a dwarfed condition until the tree is weakened by another agency, thus giving the borer a chance to grow, in which case the life cycle may be extended to 2 years or more instead of the normal 1-year period.

The most practical means of dealing with this insect is to keep the trees resistant by proper cultivation, fertilization, pruning, and any other orchard practice that will maintain the tree in an upright, thrifty, and healthy condition. When borers are found, the most satisfactory remedy known is to cut them out with a knife, care being taken not to injure the trees.

SPOTTED APPLE-TREE BORER.[62]

The spotted apple-tree borer is sometimes of considerable importance in certain localities. Its injuries are somewhat similar to those of the roundheaded apple-tree borer, except that it more commonly works in the upper parts of the trunk and branches, giving the trees an unthrifty and sickly appearance. When abundant it frequently kills young trees and branches of older trees. The presence of this insect is most readily detected by means of the sawdust-like castings which are pushed out of the burrows or by the cankerous appearance of the infested wood. The general habitat of this native beetle ranges from Canada through the New England and Middle Atlantic States westward to Iowa, and it has also been reported from Texas. It has attracted most attention in parts of Michigan, Iowa, and Wisconsin. In addition to the cultivated apple, this insect is recorded as infesting the wild crab apple, thorn trees, and Juneberry.

The winter season is spent in the larva stage within the burrow, and during the winter preceding its transformation to the adult the insect is to be found in the pupal chamber at the upper end of its gallery, usually in the heartwood of a branch or small trunk. The mature larvæ or grubs (fig. 155), are legless, about an inch or slightly more in length, whitish, with brownish head and black jaws. In the spring the grubs change to yellowish white pupæ, about two-thirds

[62] *Saperda cretata* Newman.

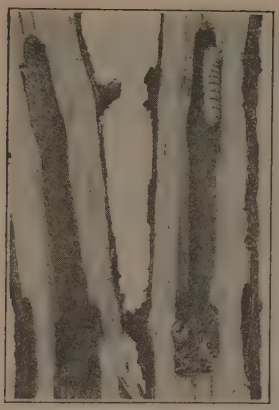

FIG. 155.—Nearly mature larva of the spotted apple-tree borer working in heart of apple wood.

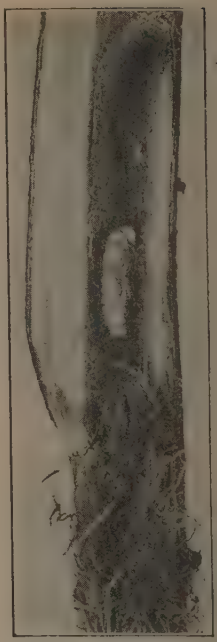

FIG. 156.—Pupa of spotted apple-tree borer.

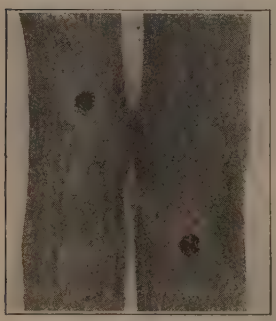

FIG. 157.—Exit holes made by beetles of the spotted apple-tree borer.

FIG. 158.—Female beetle of spotted apple-tree borer about to deposit an egg.

FIG. 159.—Apple leaf partly eaten by beetle of spotted apple-tree borer.

of an inch in length (fig. 156). Later the adult beetle gnaws its way through the bark and escapes through the small roundish exit hole (fig. 157) which has a diameter of about one-fourth of an inch. The female beetles (fig. 158) are approximately two-thirds of an inch or more in length, while those of the other sex are somewhat smaller. The brownish beetles have white sides and are most easily distinguished from the roundheaded apple-tree borer by the two white spots on each wing-cover and the white stripe on each side of the thorax. The beetles feed upon the tender bark of twigs, on leaf petioles, and also to a slight extent upon the leaves (fig. 159). The creamy white eggs (fig. 160), which soon become brownish, are inserted between the bark and the wood (fig. 161). Upon hatching the larva commences to gnaw out its burrow, and if two larvæ hatch from eggs placed in the same repository they usually feed in opposite directions, resulting in a more or less complete girdling of the branch. By the end of the first season, or early in the next, the larva usually tunnels into the heartwood, and in the case of a borer with a 2-year cycle completes its pupal chamber at the close of the second season. The general life cycle varies from 2 to 4 years, depending on latitude and other conditions, with perhaps 3 years as the common period over most of the area of its distribution.

FIG. 160.—Egg of spotted apple-tree borer. Enlarged.

FIG. 161.—Chain of punctures of spotted apple-tree borer in apple bark accompanying oviposition scar. Eggs were deposited at broad place about center of chain.

In all probability many of the beetles are killed previous to oviposition by means of the poison sprays employed against the codling moth and other chewing insects. In infested trees the larval tunnels can best be located by searching for the sawdust castings or the infested wood, as indicated by its cankerous appearance. The borers when found should be killed with a knife, wire, or other suitable tool. Where branches are heavily infested they should be pruned off and destroyed. As a further aid in reducing injury, it is advisable to cut down all of the wild host plants growing in the neighborhood of the orchard, thereby destroying natural breeding grounds.

APPLE CROTCH-BORER.[63]

The apple crotch-borer is of comparatively minor importance, although if searched for it may frequently be found in the roughened crotches of apple trees (fig. 162) or in bark wounds caused by other borers, by diseases, implements, etc. The injury is caused by the larvæ (fig. 163), which feed in the inner bark or occasionally make shallow burrows into the sapwood. Their presence results in slight injury to the tree, except in instances of severe infestation, when the affected part may be killed or in extreme cases the tree itself may die. The same trees

[63] *Aegeria pyri* Harris; also known as the pear borer.

are usually attacked year after year on account of the roughened or broken areas of the bark, and these places are preferred by the larvæ for feeding purposes. The apple crotch-borer is a native pest; it is rather generally distributed in the Eastern States and has also been found farther West—in Michigan, Missouri, Mississippi, and Texas. The recorded food plants, in addition to the apple, include the juneberry, thorn, mountain ash, and black-knot of the cherry.

During the winter the insect is in the larva stage, well protected in its silken hibernaculum, which is formed within its burrow. In the spring a cocoon (fig. 164) is made, usually beneath the bark scales, after which the

FIG. 162.—Young apple tree injured at crotch by the apple crotch-borer.

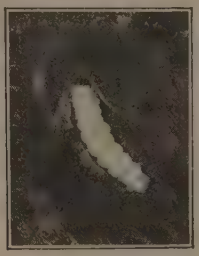

FIG. 163.—Larva of apple crotch-borer in hibernaculum.

FIG. 164. — Cocoon of apple crotch-borer, exposed by removing scales of apple bark. Enlarged.

FIG. 165. — Adult moth of apple crotch-borer. Enlarged.

FIG. 166.—Eggs of apple crotch-borer. Enlarged.

pupa stage is entered. The full-grown larva is yellowish white, with a brown head, and averages about three-fifths of an inch in length. The brownish pupa is about one-third of an inch long. The adult, which issues during the summer, is a small moth (fig. 165) with a wing expanse of one-half to three-fourths of an inch. It has clear, fringed wings, the tips of which are metallic black. The upper part of the moth is purplish black, marked with white and yellow on the head, yellow on the thorax, and with three more or less distinct yellowish bands on the abdomen. The lower parts of the moth, including the legs, are conspicuously marked with golden yellow. The moths deposit their very minute, oval, glistening, brownish eggs (fig. 166) on roughened surfaces or in cracks or other broken places of the bark. Upon hatching, the larvæ feed on the inner bark as described. According to the life-history studies of the Bureau of Entomology, some individuals have a 1-year life cycle, while others

require 2 years to complete their transformation from the egg to the adult stage, this difference being attributed to climatic and food conditions and the time of hatching.

Fortunately this borer works close to the bark surface, making it a comparatively easy matter to remove the larvæ with a knife without inflicting much injury to the tree. After the roughened bark has been scraped and the borers removed, it is advisable to paint the surfaces with either a coal-tar creosote or pure white-lead paint. If these surfaces are repainted from time to time, new infestations will be largely prevented. While this insect is not always readily detected, its location is usually indicated by a small drop of moisture and the dark pasty-like frass which is exuded from the feeding area.

FIG. 167.—Aerial colonies of the woolly apple aphis.

WOOLLY APPLE APHIS.[64]

The woolly aphis is unlike the other aphids found on the apple in that it attacks the tree both above and below ground. The aerial colonies when abundant are quite conspicuous (fig. 167). They are found upon the trunk, limbs, and twigs, being concentrated on tender growth or wherever the wood has been injured, as by tree-crickets, the periodical cicada, etc. The aphid colonies appear as whitish, cottony masses, beneath which are the reddish insects themselves. The twigs often become more or less deformed as a result of the attack. On the roots the aphids cause swellings and deformities (fig. 168) which often involve most of the roots of the tree, resulting in a sickly or stunted tree of but little fruiting capacity. It has been recently determined that the woolly apple aphis is native to America. Its present occurrence is wide, it being found in practically all of the apple-growing districts of the world. It is particularly serious in the semiarid regions of the West, where the dry climatic conditions apparently favor its development. The principal food plants are the apple and elm, and those of lesser importance include thorn apple, quince, pear, and mountain ash.

The life history of this insect is rather intricate. Briefly, winter eggs are laid in crevices of the bark on the elm and occasionally on the apple. The eggs deposited on the former are brownish and are covered with delicate, waxy hairs, and they hatch in the spring with the opening of the elm leaf buds, upon which the young aphids feed. As soon as winged aphids are produced on the elm some migrate to the apple, where they establish colonies which feed thereon during the summer. In addition to wintering in the egg stage, some wingless individuals remain above and below ground on the apple in certain districts where the winters are not too severe. Some of the root forms remain under-

[64] *Eriosoma lanigerum* Hausmann.

ground throughout their life. The wingless viviparous females are of a salmon brown color, changing with age to dark brown or purplish. The body is more or less concealed beneath a white, waxy covering, forming long, white tufts on the posterior parts. The winged viviparous females are brown to purplish, with dark brown to black head and thorax, depending on age. The body is covered with white or bluish white waxy threads, more prominent on the posterior portion. The wings are transparent and the appendages are partly black.

The aphid colonies above ground may be killed by means of a contact spray, as 40 per cent nicotine sulphate, three-eighths of a pint to 50 gallons of soapy water, made by dissolving 2 pounds of soap, or by the use of 10 per cent kerosene emulsion. Since these insects are well protected by their woolly covering the spray must be forcibly applied, care being taken to soak each colony very thoroughly. It is extremely difficult to effect satisfactory control of the root-infesting forms. Many treatments, such as tobacco refuse applied about the roots, fumigation with carbon disulphid, etc., have been tried, but none can be unqualifiedly recommended. The most practical method is to fertilize and cultivate the trees so as to keep them in a thrifty, growing condition in spite of the aphids that may inhabit the roots.

FIG. 168.—Nodular roots as a result of woolly apple aphis attack.

MISCELLANEOUS INJURIES.

Although the primary purpose of this publication is to acquaint the fruit grower with the injuries and means of control of the more important apple insects, it is believed that brief mention of other agencies, exclusive of diseases which at times occasion more or less damage, may be of some interest and value.

FROSTS AND FREEZES.

The occurrence of heavy frosts and freezing temperatures shortly after the fruit has set or while it is still quite small frequently results in deforming the fruit, the skin of which will often be marked with the so-called frost ring or band (fig. 169), which appears as a more or less distinct belt of brown corklike tissue. These frost bands sometimes completely encircle the fruit and are often conspicuous at harvest. In some instances small cracks develop in the affected area. Another type of frost injury is sometimes in evidence at the calyx or blossom end (fig. 170), in which will be found one or more small pockets or pits. Since it is practically impossible to fill these pits with poison, such fruit is quite susceptible to codling-moth injury.

HAIL.

The attempts of orchardists to grow perfect fruit are often vitiated by uncontrollable factors, among which hail plays an important rôle. Hailstorms of varying severity occasion local losses in one part of the country or another

practically every year. If the injury does not occur too near harvest, the hail pits will usually heal over as small corky areas. The damage, however, is not confined to the hail marks, since pronounced codling-moth injury sometimes follows in the wake of the hail, particularly when the storm occurs during the active hatching period of this pest, which gains ready access to the flesh of the fruit by way of the broken skin. Apples on the outside and exposed portions of the trees are naturally injured the most, and it sometimes happens that only one side of the tree is affected, depending upon the direction from which the storm has come.

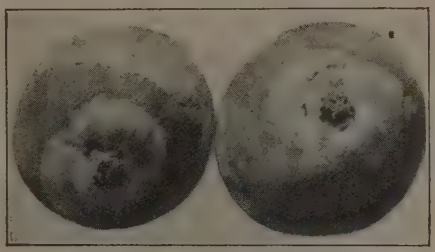

FIG. 169.—Apples injured by frost, producign the so-called "frost ring."

WIND.

The wind is at times responsible for a certain amount of injury to the fruit, causing the so-called "limb rub." The skin of apples thus affected is more or less discolored where it has been bruised by chafing against a branch or limb.

SPRAY BURN.

Spray solutions, such as combinations of arsenate of lead and lime-sulphur or arsenate of lead and Bordeaux mixture, sometimes cause distinct injury to the fruit and foliage. The fruit is often russeted (fig. 171), especially when the spray is applied too forcibly, and in the case of mixtures containing Bordeaux when used during the calyx and first cover-spray treatments or later in the season when followed by much damp or rainy weather. The foliage may be injured by either of the foregoing combinations, and this is particularly true in the case of weak and unthrifty trees. Lime-sulphur injury to the fruit often follows if the spray is applied during midsummer, under conditions of high temperature and bright sunshine. The affected fruit is greatly disfigured by a somewhat circular brownish black spot, which is sometimes as large as or larger than a half dollar (fig. 172). Apples on the southwest side of the tree are most likely to be damaged. In the eastern United States this type of injury has rarely been commercially serious, though sometimes conspicuous. In hot, sunny regions, where this form of injury is of frequent occurrence, fruit growers should use the sulphur sprays only in the cooler spring weather.

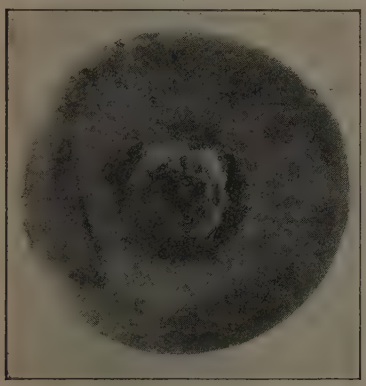

FIG. 170.—Frost injury, calyx end of apple. Codling moth larvæ frequently enter the apple through the frost pits

INJURIES FROM TREE INJECTIONS.

Every now and then "tree doctors" put in an appearance and endeavor to sell materials which they guarantee will free the tree of all noxious pests.

Usually these compounds are to be injected into the tree trunk on the theory that they will be carried by the sap to all parts of the tree, thereby destroying the undesirable parasites. Such injections are without value and may cause severe injury (fig. 173). Fruit growers would do well to employ only the materials and methods recommended by their State experiment station or the United States Department of Agriculture.

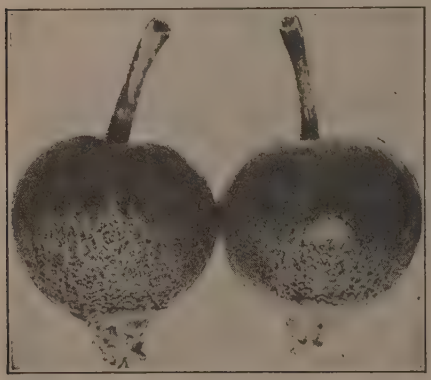

FIG. 171.—Apples russeted by Bordeaux mixture.

SUN SCALD.

During very hot periods the fruit, particularly that on the southwest side of the tree, may be heated to such an extent as to cause large dark discolorations of the skin. Where this trouble is prevalent the damage may be somewhat reduced by not pruning the susceptible portion as heavily as the rest of the tree. The trunks of trees, especially those in young orchards, are sometimes blistered on the southwest and west sides by the hot afternoon sun. A similar type of injury is more commonly produced by severe winter freezing and rapid thawing by the afternoon sun. To overcome this trouble trees may be protected by shading them with wooden strips driven into the ground rather close to the tree. The planting of high-growing cover crops or the intercropping of the young orchard with corn or other tall crops will also serve to protect the trees from too strong an exposure during the summer season.

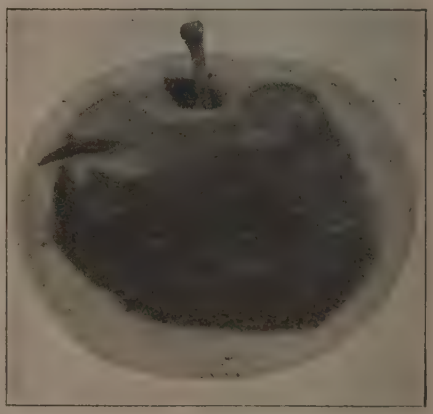

FIG. 172.—Typical lime-sulphur burning on apple.

SPRAY MATERIALS.[65]

In connection with the control of apple insects and diseases, many insecticides and fungicides have been employed both in an experimental way and in actual orchard practice. In addition to the so-called standard spray materials commonly used by commercial orchardists a very large number of proprietary compounds are now on the market. Since the active ingredients of the latter are usually made up of one or more of the standard spray materials, combined with fillers of inert substances, it is obvious that there is no particular reason for using them in preference to the standard spray materials. As a matter of economy and efficiency, the apple grower

[65] For more complete information on spray materials see United States Department of Agriculture Farmers' Bulletin 908.

would do well to employ the spray materials enumerated below, which, if rightly used, will give satisfactory results against the more important apple insects and fungous diseases.

ARSENATE OF LEAD.

Arsenate of lead is the most reliable and efficient poison for chewing insects. It is sold in both the powder and paste forms, the former being preferable, since it is more readily handled and can be held over from one year to the next by keeping it in a dry place. It can be combined with nicotine solutions and with either lime-sulphur or Bordeaux mixture for the simultaneous control of chewing and sucking insects and fungous diseases.

NICOTINE.

Nicotine, either commercial, as 40 per cent nicotine sulphate, or homemade decoctions, is the best contact insecticide for sucking insects such as apple aphids, red bugs, etc. If used alone, soap should be added as a spreader, but if combined with mixtures containing lime-sulphur solution the soap should be omitted. When added to Bordeaux mixture and arsenate of lead a pound or so of soap to 50 gallons of spray may be used if desired.

KEROSENE EMULSION.

Kerosene emulsion is a relatively cheap and effective contact spray for sucking insects, but unless very well made and carefully used it may cause foliage injury. It has a further disadvantage in that it can not be used in combination with the other standard spray materials.

LIME-SULPHUR.

FIG. 173.—Tree injured by use of compound sold by "tree doctor."

Lime-sulphur is used both as an insecticide and as a fungicide. It is recommended as a dormant spray against the scale insects and blister mite, and at greatly diluted strengths as a summer spray for apple scab and certain other diseases.

BORDEAUX MIXTURE.

The well-known fungicide, Bordeaux mixture, is used against certain diseases, notably apple bitter-rot, which are not held in check by lime-sulphur.

SOLUBLE OILS.

Soluble or miscible oils, homemade or proprietary, may sometimes be employed to advantage as dormant sprays for scale insects, the fruit-tree leaf-roller, etc. Injury may follow from their use, and it is therefore safer to apply lime-sulphur solution for scale insects.

DUSTING MATERIALS.[86]

The dry application of insecticides and fungicides has been tried experimentally and commercially for many years. In some instances satisfactory re-

[86] For more complete information on dusting materials see United States Department of Agriculture Farmers' Bulletin 908.

sults have been obtained, but, on the whole, dust mixtures have not given as efficient control as liquid sprays, and in certain apple districts have been quite ineffective. The dust mixtures now usually employed contain 10 per cent of lead arsenate and from 75 to 90 per cent of finely divided sulphur. A filler, such as hydrated lime or gypsum, is often desirable, as its admixture makes a better flowing dust and lessens the cost of the mixture. It is believed that a 75 per cent sulphur content will yield as good results as a higher percentage. A complete dust mixture, containing arsenate of lead, sulphur, and nicotine, has been tried out during the past few years, the nicotine having been added in an effort to combat apple aphids, red bugs, etc. Some success has been reported with this mixture, but the quantity of nicotine required makes the application somewhat expensive. An effort is now being made to develop a good copper sulphate and lime dust to replace the sulphur. Some promising results have been obtained, but further tests are necessary to determine fully its efficiency against fungous diseases.

FIG. 174.—Construction of tree band made of cotton and tarred paper.

TREE-BANDING MATERIALS.[67]

Bands of sticky material 4 to 5 inches wide applied around tree trunks sometimes may be used to advantage to prevent caterpillars, climbing cutworms, and certain other insects from climbing trees. These bands are also employed to prevent nonflying and wingless moths, such as the gipsy moth, cankerworm moths, tussock moths, etc., from ascending trees to deposit their eggs. Cotton batting and wire screen also are used in making protective bands.

The indiscriminate use of these bands, as well as mechanical barriers, is to be discouraged. Their use in parks is sometimes noted on trees which are not subject to attack by insects against which they would have value. As a rule, it is advisable to obtain advice as to their use from entomologists.

FIG. 175. Completed tree band of cotton and tarred paper with band of sticky material.

STICKY TREE BANDS.

Sticky bands are sometimes injurious to the tree, but injury may be avoided by spreading the adhesive on a strip of heavy paper encircling the tree trunk.

[67] For more complete information on tree-banding materials see United States Department of Agriculture Farmers' Bulletin 908.

A form of band that has given satisfactory results is made from cheap cotton batting and single-ply tarred building paper. The cotton should be cut into strips about 2 inches wide and wrapped around the tree trunk so as to fill all the crevices of the bark. Over the cotton is placed a strip of tarred paper (fig. 174) about 5 inches wide, drawn tightly and securely tacked where it overlaps. The sticky material is then spread on top of the paper (fig. 175).

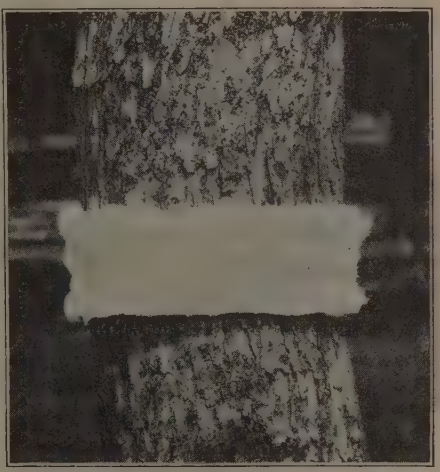

FIG. 176.—Method of construction of cotton tree band.

COTTON BATTING.

Barriers other than sticky bands are sometimes used to prevent insects from crawling up trees.

Bands of cotton batting about 6 to 8 inches wide are effective as long as the cotton remains fluffy. Wrap the band around the tree trunk and securely tie the bottom edge by means of stout twine (fig. 176). The upper edge should then be turned down over the string, forming a flange of loose cotton all around the tree (fig. 177).

SPRAYING APPARATUS.[68]

It is generally recognized by progressive fruit growers that the sprayer and its equipment are very important factors in the production of clean fruit. Fortunately, it is possible to obtain satisfactory outfits which, with proper care and attention, will give years of good service. Although the first cost of a well-made sprayer may appear somewhat high, no fruit grower can afford to be without a reliable outfit that will meet his requirements during the critical spray periods. The purchase of an efficient sprayer is an investment that will pay very liberal dividends. The capacity of an outfit should be larger than needed under ideal working conditions, since unfavorable and unforeseen circumstances may interfere and make it necessary to have reserve power with which to complete the work in time. Large-scale operators should have an extra

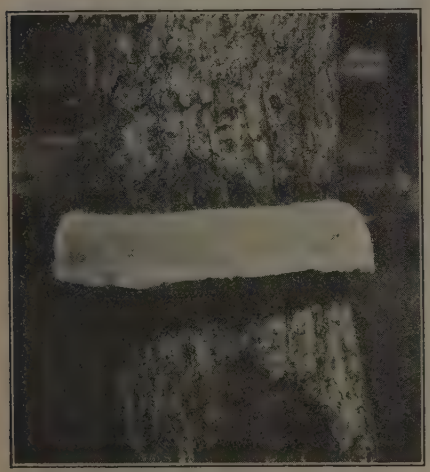

FIG. 177.—Completed cotton tree band.

[68] For more complete information on spraying apparatus see United States Department of Agriculture Farmers' Bulletin 908.

sprayer or two to provide against emergencies, and extra parts should be kept on hand to replace those that are broken or worn.

FIG. 178.—A power spray outfit equipped with tower for spraying tall trees.

For those having relatively few trees, a hand-pump outfit, as a barrel pump, may suffice, but generally speaking it is better economy to employ a power sprayer (fig. 178), even in the case of comparatively small acreages. Reliable power outfits are made in different sizes to meet the demands of small to large growers.

The hose and couplings should be of the best materials, since these are subject to considerable pressure and strain, particularly in the case of high-power sprayers.

The selection of the proper spray nozzles, rods, or spray guns will depend largely upon the capacity of the outfit and other factors.

A power machine for applying dust materials is shown in figure 179.

APPLE-SPRAYING SCHEDULES.

As has been explained in the foregoing pages, fruit trees and fruits are simultaneously attacked by many insects and fungous diseases, as the codling moth, plant-lice, apple scab, etc. It is therefore desirable, and fortunately possible, by a combination of insecticidal and fungicidal materials, to effect the control of these several troubles by one and the same spray application, as by a spray of dilute lime-sulphur, arsenate of lead, and 40 per cent nicotine sulphate. Entomologists and pathologists have given much study to developing combination treatments of this kind in order to save the grower the extra cost and time of separate treatments. Also, spray schedules have been developed for the more important insect and fungous diseases of the apple, peach, grape, and the like. While it is always desirable that an orchardist know as much as possible about his insect and fungous pests, yet he will be able to obtain much success in their control simply by carefully following a series of spray applications timed so as to treat most effectively the various troubles present on the trees or fruit. Although it is not possible by the following of

FIG. 179.—A power dusting outfit at work.

spray schedules to control all of the troubles of the apple, a very large proportion of those controllable by sprays can be kept down by the use of the spray-schedule plan. In the subsequent pages schedules are presented covering the principal orchard districts of the country, which may be modified in accordance with the needs of individual orchardists. In this connection, it should be borne in mind that the relative abundance of pests varies from year to year as influenced by weather and other conditions. The apple grower should therefore be constantly on the alert and prepared to cope with any unusual conditions that may arise from time to time. If the fruit grower is not well acquainted with his insect and fungous troubles, he will do well to consult the State agricultural experiment station, the United States Department of Agriculture, or some other competent agency interested in the suppression of orchard pests.

FIG. 180.—Proper stage at which to begin calyx application.

THE CALYX SPRAY.

The so-called "calyx spray" or "petals-off" application is generally recognized as the most important spray for the apple during the growing season and is particularly valuable against the codling moth. The primary object of this application is to fill each calyx cup with poison in order to kill the worms that attempt to enter the fruit through the calyx or blossom end. The time within which this spray can be effectively applied is limited and every effort should be made to do the work within the prescribed period. The spraying should be begun as soon as the petals have dropped (fig. 180) and should be completed before the calyx cups have closed (fig. 181). As an insurance in covering the orchard in time it is often desirable to begin the spraying when 85 to 90 per cent of the petals have dropped, but care should be taken not to spray earlier on account of possible injury to the honeybees.

FIG. 181.—Too late to make calyx application.

It is well known that certain varieties of apples bloom earlier than others and that with each variety there is more or less variation in the development of the bloom. The orchardist should therefore carefully inspect the blossoms and time the spraying with reference to those most advanced. Under ordinary circumstances the center blossom is the most advanced and the most likely to set fruit.

The development of the calyx cup of the Baldwin from the time the petals fall until the cup has closed is shown by means of the vertical sections in figures 182, 183, 184, and 185. In figure 182, which represents the cup just after the dropping of the petals, it will be noted that the sepals are about at right angles to the flowering parts and form a broad, shallow cup which can be readily coated with the poison spray. Six days later,

FIG. 182.—Vertical section of apple calyx cup. Petals have just dropped.

FIG. 183.—Vertical section of apple calyx cup six days after petals dropped.

FIG. 184.—Vertical section of apple calyx cup eight days after petals dropped.

FIG. 185.—Vertical section of apple calyx cup ten days after petals dropped.

as shown in figure 183, the sepals have grown upward, making the cup somewhat V-shaped. In figure 184, which represents the cup 8 days after the petals have dropped, the sepals have advanced further toward the closing point, forming a U-shaped cup. Spraying at this stage is still effective, since the cup is open sufficiently to admit the poison. Two days later, however, or a total of 10 days after the petals have dropped, as shown in figure 185, the sepals have grown together and the cup is practically closed. At this stage of development it is impossible to force the poison into the cup, and hence too late to apply the calyx spray.

The rapidity of closing of the calyx cup varies somewhat with the variety and with the weather conditions. If the spraying is begun when 85 to 90 per cent of the blossoms have dropped, the time within which the calyx application should be made will usually cover a period of a week to 10 days. The orchardist, however, should not depend upon the longer period, but, instead, should provide against unfavorable weather and other unforeseen interruptions by employing sufficient help and spray machines to complete the work within a week.

TABLE I.—*Apple-spraying schedules.*[1]

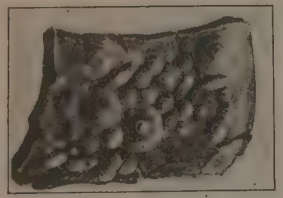

FIG. 186.—San Jose scale. Enlarged.

FIG. 187.—Proper stage at which to make delayed dormant application.

Time of dormant and delayed dormant applications.	Spray materials and dilutions.	Dormant and delayed dormant applications for all fruit districts.
"Dormant."—The dormant spray may be applied at any time (except during freezing weather) after the leaves drop in the fall until the buds swell in the spring. As a matter of economy and efficiency it is preferable to make the dormant application after the trees have been pruned. This treatment is chiefly for the control of the scale insects and pear-leaf blister-mite.	Concentrated lime-sulphur (32° Baumé), 6½ gallons with water to make a total of 50 gallons. For the blister-mite 5½ gallons of lime-sulphur diluted to 50 gallons is effective.	It is very important to spray all scale-infested orchards, using lime-sulphur solution at the strength indicated. In California, crude-oil emulsion is extensively employed against scale insects. If mildew is prevalent, the pruning off of the mildewed tips during the dormant period will aid in checking the disease.
"Delayed dormant."—If, in addition to scale insects, aphids are present, the above dormant treatment may be delayed until the bud tips show green. The trees should be sprayed at this time with dormant strength lime-sulphur and nicotine, a combination which is effective against scale insects and aphids. The spraying should be completed by the time the leaf tips have commenced to separate in order to avoid possible injury to the unfolding buds and to obtain satisfactory results against the aphids. If it is desired to spray for the aphids only, use the same quantity of nicotine, adding 2 pounds of soap to each 50 gallons of water.	Use lime-sulphur as directed above for the scale insects, adding ⅔ pint of 40 per cent nicotine sulphate to each 50 gallons. Do not add soap to the above combination.	This is the most important single spray application for apple aphids, since at this time they are clustered on the bud tips and thus fully exposed to the spray. In large orchards, however, there is some danger in delaying the treatment for scale insects until this time, since unfavorable weather conditions may prevent covering the orchard within the specified period.

[1] Directions for control of fungous diseases furnished by Bureau of Plant Industry, United States Department of Agriculture.

FIG. 188.—Much too late to make delayed dormant application. Note apple aphids feeding at base of leaves. In most sections the first application for apple scab should be made at this stage.

Time of summer spray applications for the more important insects and fungous diseases.	Spray materials and dilutions.
"Pink cluster-bud."—This spray should be applied when the blossom buds first begin to separate and should be completed before any of the blossoms open. It is a very important application for apple scab wherever this disease is prevalent. It is also of value in the control of the plum curculio, tent caterpillars, canker worms, etc. If aphids are present and the leaves are not too badly curled, the addition of nicotine to the spray will aid somewhat in reducing the infestation.	For chewing insects and fungous diseases use arsenate of lead powder 1 pound, or paste 2 pounds, combined with lime-sulphur (32° Baumé) 1½ gallons diluted with sufficient water to make 50 gallons. Nicotine sulphate (40 per cent), at the rate of ⅔ pint, may be added to the above for apple aphids and red bugs.

New England States.	Middle Atlantic States.	Southern Atlantic States.	Ohio Valley.	Great Lakes.
I. Arsenate of lead and lime-sulphur.	I. Arsenate of lead and lime-sulphur.	I. Arsenate of lead and lime-sulphur.	I. Arsenate of lead and lime-sulphur.	I. Arsenate of lead and lime-sulphur.

Central Mississippi Valley and the Ozark district.	West-Central States.	Semiarid Western States.	Pacific Northwest.	California.
I. Arsenate of lead and lime-sulphur.	I. Arsenate of lead and lime-sulphur.		I. Arsenate of lead and add lime-sulphur if apple scab, powdery mildew, or other fungous diseases are present.	

TABLE I.—*Apple-spraying schedules*—Continued.

FIG. 189.—Proper time to make calyx application.

Time of summer spray applications for the more important insects and fungous diseases.	Spray materials and dilutions.
"Calyx" or "petals-off."—Spray as soon as blossom petals have dropped and complete the application before the calyx cups have closed. Use good pressure and spray thoroughly so as to fill every calyx cup. This is the most important single application for the codling moth and is of value against the plum curculio, apple scab, etc.	Arsenate of lead and lime-sulphur as in the first summer application.

New England States.	Middle Atlantic States.	Southern Atlantic States.	Ohio Valley.	Great Lakes.
II. Arsenate of lead and lime-sulphur.	II. Arsenate of lead and lime-sulphur.	II. Arsenate of lead and lime-sulphur.	II. Arsenate of lead and lime-sulphur.	II. Arsenate of lead and lime-sulphur.

Central Mississippi Valley and the Ozark district.	West-Central States.	Semiarid Western States.	Pacific Northwest.	California.
II. Arsenate of lead and lime-sulphur.	II. Arsenate of lead and lime-sulphur.	I. Arsenate of lead. Fungicides are seldom necessary.	II. Arsenate of lead and add lime-sulphur if fungous diseases are present.	I. In Pajaro Valley use neutral arsenate of lead and iron sulphid in all summer applications.

FIG. 190.—Apples infested with the codling moth.

Time of summer spray applications for the more important insects and fungous diseases.	Spray materials and dilutions.
"Two to four weeks after 'petals-off' application."—This application is important for the first brood of the codling moth which begins to hatch within this period and for other chewing insects, apple scab, leaf-spot, and blotch. Where blotch has been prevalent, use Bordeaux mixture in place of the lime-sulphur, and complete the spraying not later than 3 weeks after the falling of the petals. In certain sections where blotch is epidemic, an intermediate spray application should be given about midway between the above and that indicated below.	Arsenate of lead and lime-sulphur as in the first summer application, except that Bordeaux mixture (3-4-50) should be used in place of the lime-sulphur in districts where blotch is present.

New England States.	Middle Atlantic States.	Southern Atlantic States.	Ohio Valley.	Great Lakes.
III. Arsenate of lead and lime-sulphur.	III. Arsenate of lead and Bordeaux mixture in place of lime-sulphur in sections having varieties susceptible to blotch.	III. Arsenate of lead and Bordeaux mixture in place of lime-sulphur in sections having varieties susceptible to blotch. Where blotch is severe make an intermediate application midway between III and IV.	III. Arsenate of lead and Bordeaux mixture in place of lime-sulphur in sections having varieties susceptible to blotch. Where blotch is severe make an intermediate application midway between III and IV.	III. Arsenate of lead and lime-sulphur.

Central Mississippi Valley and the Ozark district.	West-Central States.	Semiarid Western States.	Pacific Northwest.	California.
III. Arsenate of lead and Bordeaux mixture in place of lime-sulphur. In sections where blotch is severe make an intermediate application midway between III and IV.	III. Arsenate of lead and Bordeaux mixture in place of lime-sulphur in sections having varieties susceptible to blotch. Where blotch is severe make an intermediate application midway between III and IV.	II. Arsenate of lead. Where the codling moth is abundant make one or two additional applications between II and III.	III. Arsenate of lead. In certain sections an intermediate spray for the codling moth between III and IV will be of value.	II. Neutral arsenate of lead and iron sulphid.

TABLE I.—*Apple-spraying schedules*—Continued.

FIG. 191.—Fall webworm caterpillars and others are common during midsummer.

Time of summer spray applications for the more important insects and fungous diseases.	Spray materials and dilutions.
"Eight to ten weeks after 'petals off' application."—A very important application in all districts having two or more broods of the codling moth and for many species of caterpillars and other chewing insects as well as for bitter-rot, blotch, and late scab infection. Where bitter-rot has been serious spray about 6 to 7 weeks after "petals off" application.	Same spray materials as above except that if Bordeaux mixture is used the 4-4-50 formula should be employed.

New England States.	Middle Atlantic States.	Southern Atlantic States.	Ohio Valley.	Great Lakes.
IV. Arsenate of lead and lime-sulphur.	IV. Arsenate of lead and Bordeaux mixture in place of lime-sulphur in sections having varieties susceptible to bitter-rot and blotch.	IV. Arsenate of lead and Bordeaux mixture in place of lime-sulphur in bitter-rot and blotch districts.	IV. Arsenate of lead and Bordeaux mixture in place of lime-sulphur in bitter-rot and blotch districts.	IV. Arsenate of lead and lime-sulphur.
Central Mississippi Valley and the Ozark district.	**West-Central States.**	**Semiarid Western States.**	**Pacific Northwest.**	**California.**
IV. Arsenate of lead and Bordeaux mixture.	IV. Arsenate of lead and Bordeaux mixture.	III. Arsenate of lead.	IV. Arsenate of lead.	III. Neutral arsenate of lead and iron sulphid.

FIG. 192.—Wormy apple due to the codling moth.

Time of summer spray applications for the more important insects and fungous pests.						Spray materials and dilutions.
Additional treatments where the codling moth and bitter-rot are prevalent. Where late spraying is necessary, the fruit at harvest may be more or less covered with spray residue. This should be removed from the fruit before it is barreled or boxed.						Same spray materials as above.
Southern Atlantic States.	Ohio Valley.	Central Mississippi Valley and the Ozark district.	West-Central States.	Semiarid Western States.	Pacific Northwest.	
Depending upon the locality, varieties, weather, and other conditions, from two to four additional treatments of arsenate of lead and Bordeaux mixture will often be necessary.	Depending upon the locality, varieties, weather, and other conditions, from two to four additional treatments of arsenate of lead and Bordeaux mixture will often be necessary.	One or two additional treatments of lead arsenate and Bordeaux mixture about 2 weeks apart and in severe bitter-rot cases make additional applications of the Bordeaux arsenate of lead spray.	If the codling moth and bitter-rot are prevalent, apply additional sprays of arsenate of lead and Bordeaux mixture.	In the control of the codling moth it will often be necessary to make one or two additional treatments after III.	In the control of the codling moth it will often be necessary to make one or two additional treatments after IV.	